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SRN6

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SRN6

a high performance overwater transport

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SRN6

A HIGH PERFORMANCE OVERWATER TRANSPORT

The successful development by the British Hovercraft Corporation (B.H.C.) of the flexible skirt made it possible to design a small hovercraft which had a practical over-water and cross-country capability.

Before the development of the flexible skirt it was estimated that it would be necessary to hover at least 4-5 ft. above the ground to cope with the obstacle clearance requirements, and at least 3 ft. over water. To achieve these clearance heights and to be economically competitive, such a craft would have to be of 150 to 250 tons all-up weight.

The development of the flexible skirt has made it possible for a 7-ton craft such as the SR.N5, to have the same obstacle clearance and overwave performance as a 150 to 250 ton craft.

This work was carried out on the experimental SR.N1 which in 1962 was fitted with 4 ft. flexible skirts. Prior to this the craft could clear only 6-9 in. obstacles; with the 4 ft. skirts it traversed 3 ft. 6 in. walls, 6 ft. hedges, and 20 ft. wide ditches, despite an increase in all-up weight to 7 tons. These trials were so successful that B.H.C. was able to give immediate reconsideration to the requirement for a small hovercraft with a really practical cross-country and rough-water capability. The SR.N5 emerged from this experimental work and rapidly achieved considerable success both at home and abroad.

The SR.N5 has a considerable over-land performance and, as operating experience accumulated, it became obvious that its load-carrying capacity as a marine craft could be more than doubled. The SR.N6 has been designed to give the necessary increase in cubic capacity without reducing the over-water performance achieved by the SR.N5. Consequently the SR.N6 makes an attractive and economical commercial ferry.

The SR.N6 is now operating on scheduled passenger-carrying services including the English Channel and on specialised operations in the oil industry. The craft can be adapted to a variety of other roles, the degree of modification being dependent on customer requirements.

Being truly amphibious, highly manoeuvrable and compact in size, it can operate from relatively unsophisticated terminals, above the high water mark.

Powered by a Bristol Siddeley 'Marine Gnome' gas turbine, which has a maximum continuous rating of 900 s.h.p., and fitted with 4 ft. skirts, the SR.N6 provides a comfortable ride for 38 passengers at 40 knots in 4-5 ft. seas. In calmer conditions a maximum speed of 56 knots can be attained with full payload.

The SR.N6 embodies well-proven items which have already accumulated a substantial amount of operating experience in many parts of the world under vastly differing conditions. It incorporates the following fully developed systems and components which are also used in the SR.N5.

Engine installation, transmission, fan and propeller.
Commander's station layout and complete control system.
Fins, rudders and elevators.
Fuel, hydraulic and electrical systems.
Basic skirt system.

british hovercraft corporation limited

YEOVIL SOMERSET, AND EAST COWES ISLE OF WIGHT, ENGLAND

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the basic craft

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the basic craft

GENERAL DESCRIPTION

In the SR.N6 the optimum in design has been achieved for a hovercraft embodying a single engine, lifting fan and propeller, the prime function of which is to operate as a fast overwater transport. The design embodies features that have been well proven by extensive experience in operating the SR.N5.

The craft is of all-metal construction and the main load-carrying structure comprises two girders which run the full length of the craft and are braced by the cabin aft bulkhead.

Buoyancy tanks, sub-divided into twelve watertight compartments are located outboard of the girders and between the girders at the aft end, form a platform; a plenum chamber is round the periphery. The passenger cabin is set forward into the plenum chamber and buoyancy tanks, the floor of the cabin forming the base of the platform. As the cabin is below the waterline it contributes to the buoyancy. For added safety the floor is double skinned, the intervening space being filled with foamed plastic. Access to the cabin is by a combined bow loading door and ramp. Flexible skirts of synthetic rubber-coated fabric extend round the periphery of the plenum chamber and are suspended from outriggers mounted on the buoyancy tanks. Stability of the craft is improved by keels in cruciform arrangement in the air cushion. The skirts are constructed in segments to facilitate replacement and are attached to the structure by simple 'piano hinge' type fittings. A system of 'skirt lifting' incorporated in the skirts provides a means of accurate manoeuvring at low speed.

The integrated lift/propulsion system employs a single Bristol Siddeley 'Marine Gnome' gas turbine engine coupled to a centrifugal lift fan and a variable pitch propeller. The drive to the propeller is through two reduction gearboxes, the second gearbox also drives the lift fan through a bevel gear. The air cushion is generated by the fan which is located in the plenum chamber, aft of the cabin.

Immediately aft of the propeller is the tail unit comprising twin fins with rudders for directional control and two all-moving tailplanes for longitudinal trimming, whilst control ports, using plenum chamber air, further enhance yaw control. A ballast system provides additional means of trimming the craft longitudinally, the system contains fuel which is used for ballasting and which, in an emergency, can be transferred into the main fuel system.

The main fuel tank is sited behind the cabin and immediately below the engine. Both the engine and the fuel system are accessible for maintenance from deck level.

The SR.N6 has been designed for operation in all climates and particular care has been taken to select a skirt material that retains its flexibility even under arctic conditions. Full air conditioning, including refrigeration and heating, has been catered for in the design and can be fitted to customer's requirements.

Should the engine fail the craft has a reserve buoyancy of 370% including the cabin or 58% excluding the cabin, and sufficient lifejackets and inflatable life rafts are provided for all passengers.

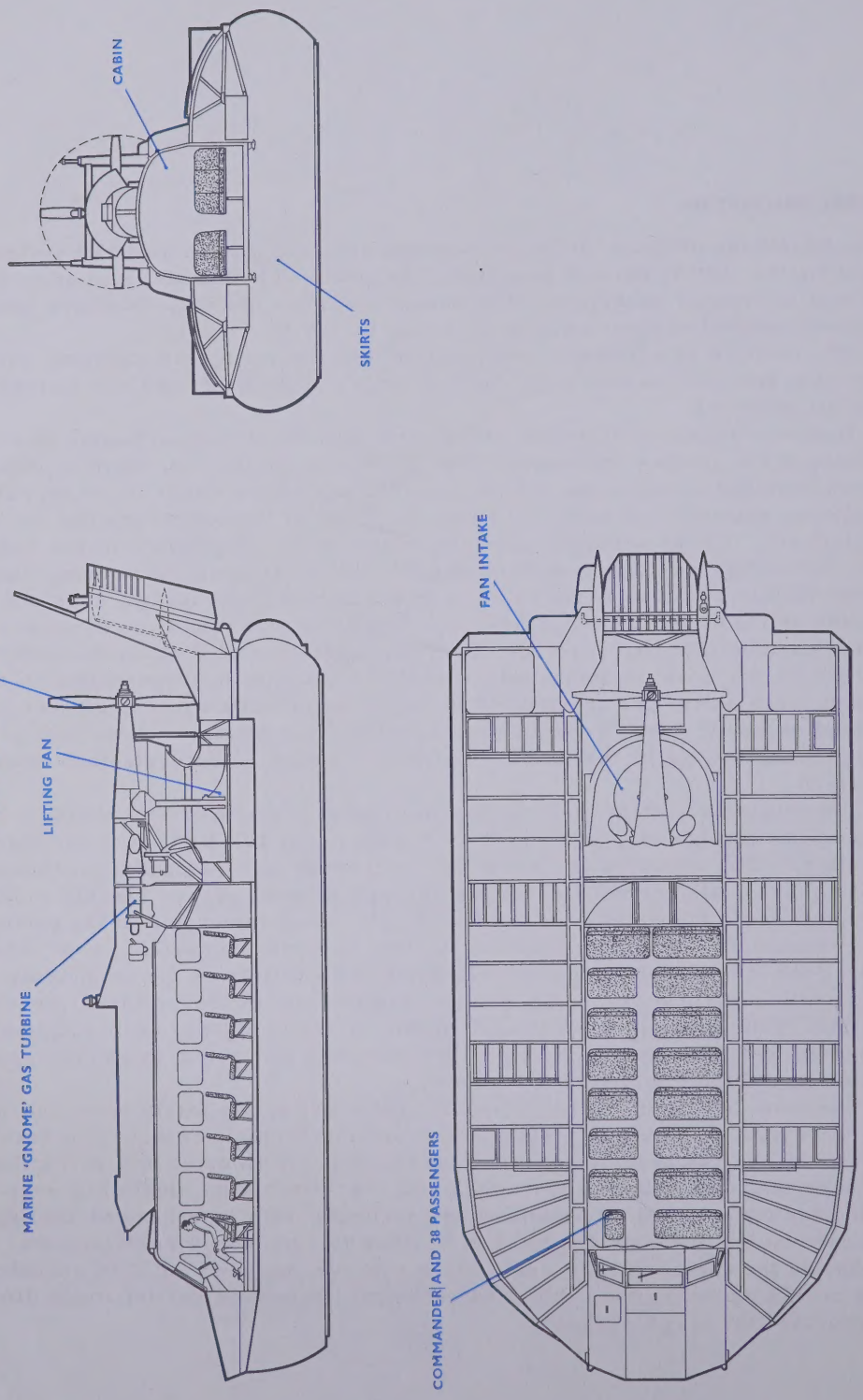

FIG. 1.1 INTERNAL ARRANGEMENT

PUBLIC TRANSPORT

The central position of the cabin and the soundproofing make this craft a highly acceptable form of transport and the stability is such that even in 4-5 ft. seas no adverse effects are experienced. Visibility is excellent and is in no way impeded by small windows or structure.

The basic seating arrangement as a public transport is for 38 passengers in 'bus'type seats.

In providing for luggage stowage it has been assumed that the craft will operate over comparatively short distances and that no large articles will be carried. Hand luggage can be stowed under the seats and any excess stores in the external panniers.

The craft is designed to operate in all weathers and is equipped with heating and ventilating facilities. Full air conditioning is available to special order. The unique bow loading doors enable a turn-round to be achieved in under two minutes.

FREIGHT TRANSPORT

For this role the seats are removed leaving a completely flat floor with a grid of freight lashing points that enables the freight to be evenly distributed as desired. The lower portion of the entrance door forms a ramp to facilitate the loading of freight.

Loads of up to 3 tons can be carried without any appreciable effect on the C.G. position, correction of any out-of-trim being within the capacity of the ballast system. Dependent upon the environmental conditions, the craft can be overloaded to carry 4 tons of freight. Under these circumstances the panniers must be loaded with freight to supplement the ballast system. Loading instructions are provided with the craft to ensure that when carrying heavy loads they are distributed in the correct manner.

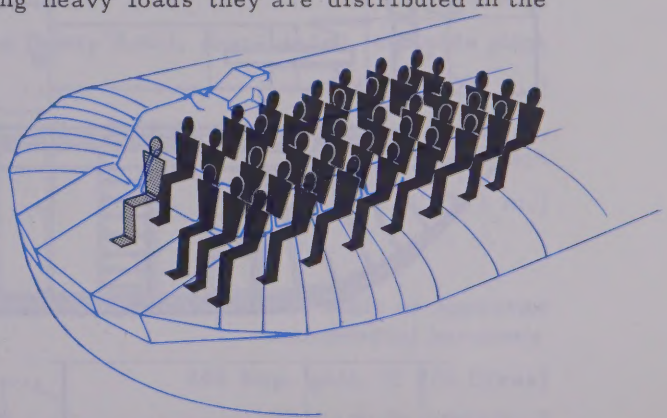

FIG. 1·2 SEATING LAYOUT

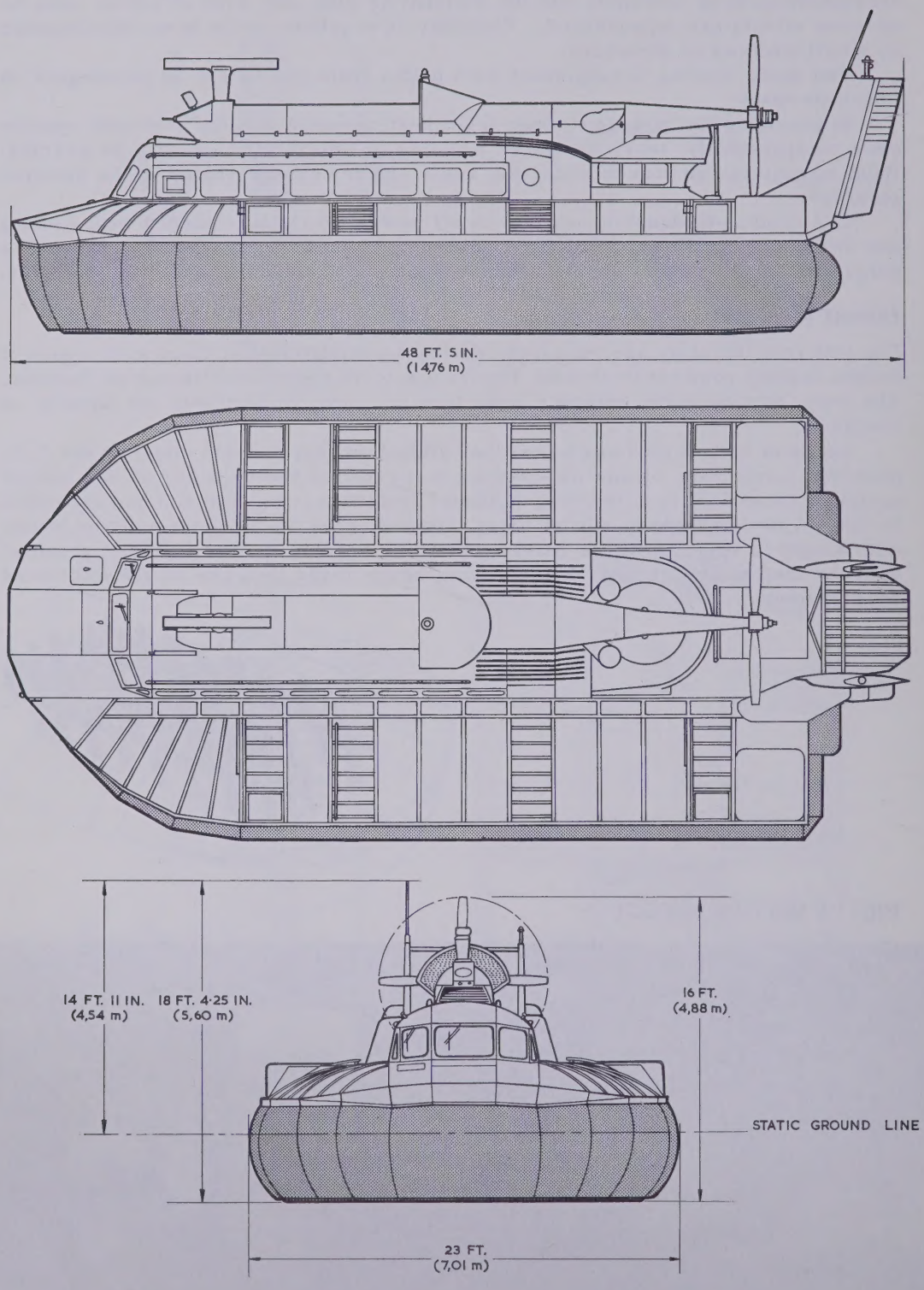

FIG. 1.3 THREE-VIEW GENERAL ARRANGEMENT

LEADING PARTICULARS

Principal dimensions

Overall length	48 ft. 5 in. (14,76 m.)
Overall beam	23 ft. (7,01 m.)
Overall height on landing pads	14 ft. 11 in. (4,55 m.)
Overall height from skirt hemline (hovering)	18 ft. 4 in. (5,59 m.)
Cabin length	21 ft. 8 in. (6,60 m.)
Cabin width	7 ft. 8 in. (2,34 m.)
Cabin floor area	166 sq.ft. (15,42 sq. m.)
Door aperture height	5 ft. 9 in. (1,75 m.)
Door aperture width	3 ft. 1 in. (0,93 m.)
Skirt length	4 ft. (1,22 m.)
Cushion area	673 sq.ft. (63 sq.m.)
Cushion load at 9 tons A.U.W.	30 lb./sq.ft. (146 kg./sq.m.)

Power and transmission

Engine	One Bristol Siddeley 'Gnome' B.S.Gn.1051
Max. rating	1,050 h.p.
Max. cont. rating	900 h.p.
Propeller type	One Dowty Rotol, four-bladed, variable pitch
Propeller diameter	9 ft. (2,74 m.)
Lift fan type	One B.H.C. centrifugal twelve-bladed, fixed pitch
Fan diameter	7 ft. (2,1 m.)

Fuel

Fuel type	Standard turbine fuels or approved commercial kerosene
Fuel tank usable capacity	265 Imp. gall. (1 205 litres)
Fuel weight	2,120 lb. (962 kg.)

Cabin layout

Passenger transport role

All seating is provided within the cabin and provision for approximately 75 cu.ft. (2 cu.m.) of baggage is available in the panniers located at the rear corners of the deck.

Fixed seating	38 passengers

Freight transport role

The quick release seat attachment fittings in the floor serve the dual function of freight lashing points.

Number of lashing points	30
Approx. lashing grid	2 rows, 4 ft. (1,22 m.) apart at 14 in. (36 cm.) pitch

WEIGHT SUMMARY

(a) Equipped to the standard of a high-density passenger transport including furnished cabin with seats, VHF radio, safety and survival equipment.

					lb.	(kg.)
Basic weight					11,410	(5 175)
Disposable load :						
	lb.	(kg.)				
Commander	200	(90)				
38 passengers at 165 lb. (75 kg.) each	6,270	(28 155)				
265 Imp. gall. of fuel	2,120	(962)				
			Tons	(Tonnes)		
Total			3.83	(3,89)	8,590	(3 897)
Normal A.U.W.			8.93	(9,07)	20,000	(9 072)

(b) Equipped to a standard suitable for night operation, fitted with night operational equipment including radar, 2 crew, and seats for 35 passengers. Cabin heating and air conditioning also included.

					lb.	(kg.)
Basic weight					12,500	(5 675)
Disposable load :						
	lb.	(kg.)				
Driver and navigator	400	(181)				
35 passengers at 165 lb. (75 kg.) each	5,780	(2 622)				
Fuel load	1,320	(599)				
			Tons	(Tonnes)		
Total			3.34	(3,39)	7,500	(3 405)
Normal A.U.W.			8.93	(9,07)	20,000	(9 072)

(c) Equipped as a freight transporter with cabin furnishing and seats removed. In this role the craft can be overloaded; typical examples are given below :-

					lb.	(kg.)
Basic weight					19,900	(4 944)
Disposable load :						
	lb.	(kg.)				
Commander	200	(90)				
Freight	6,780	(3 075)				
Fuel	2,120	(962)				
			Tons	(Tonnes)		
Total			4.07	(4,135)	9,100	(4 128)
Normal A.U.W.			8.93	(9,07)	20,000	(9 072)
Overload case						
Disposable load					12,100	(5 488)
Overload A.U.W.			10.3	(10,46)	23,000	(10 433)

PERFORMANCE SUMMARY

The following performance figures are measured average values achieved from production trials.

With the exception of the overwave, gradient and obstacle clearance data, the performance has been corrected to equivalent calm water still air conditions.

All values are quoted under I.S.A. conditions. No allowance has been made for the effects of 'plenum bleed' air intakes which have distinct advantages when operating in cold climates (de-icing) and minimise the ingress of sand and dust when operating in arid and desert areas.

It should be noted that the quoted maximum speeds assume the craft to be correctly trimmed; the 'Service Average' speed is a typical speed readily achievable by the average commander.

The 'Service Average' speed is generally 90% of the maximum, this has been substantiated from experience obtained on various 'in-service' SR.N6s.

The quoted mean operating weight represents a craft equipped to a 'daylight' standard role, operated at a load factor of 75% and with half the fuel used.

Mean operating weight	17,300 lb. (7,847 kg.)
Maximum speed (optimum trim) max. power	60 knots* (111 km./hr.)
Maximum speed (optimum trim) max. cont. power	56 knots* (104 km./hr.)
Service average speed, max. cont. power	50 knots* (93 km./hr.)
Airspeed into wind in 4-5 ft. waves (sheltered water seas)	45-55 knots (83-102 km./hr.)
Time to accelerate to 50 knots (93 km./hr.)	38 sec.
Normal stopping distance from 50 knots (93 km./hr.)	275 yd. (252 m.)
Emergency ditching distance from 50 knots (93 km./hr.)	105 yd. (96 m.)
Normal turn radius at 40 knots (74 km./hr.)	385 yd. (352 m.)
Endurance at max. cont. power	3·6 hr.
Calm water range at max. cont. power	200 n.m.
Obstacle clearance, height of vertical step	$3\frac{1}{2}$ ft. (1 m.)
Negotiable gradient from standing level start	1 : 10

* When equipped as a 'night' standard craft, these speeds will be reduced by 1 or 2 knots due to the drag effects of the radar scanner.

FURNISHINGS AND EQUIPMENT

The following is a list of equipment fitted to an SR.N6 hovercraft when equipped to the 'daylight' and night' standards.

DAYLIGHT STANDARD

Furnishings

Cabin walls and roof soundproofed and cream trim
Cabin floor covering - grey 'Lionide'
Passenger seats - sage green (38)
Commander's seat - sage green

Systems

Cabin ventilation
Cabin heating - optional extra
Cabin cooling - optional extra
Cabin lighting

Instruments

Airspeed indicator
Propeller pitch indicator
Power turbine r.p.m. indicator
Power turbine inlet temperature gauge
Gas generator r.p.m. indicator
Oil pressure gauge
Oil temperature gauge
Oil contents gauge
Fuel contents gauge
Fuel ballast gauge
Generator ammeter
Engine oil pressure (2)
Inclinometer

Warning Lamps

Main oil pressure
A.c. failure
Fire warning
Engine starter switches
Engine overspeed/overtemperature warning lamp

Auxillary Controls

Steaming light switcn
Instrument lights switch
Cabin air intake shutter control
Press-to-transmit switch
Ignitor switch
L.P. fuel cock lever
Cabin heater switch
Ventilating fans switch
Windscreen heating switch
Fuel pump circuit breaker
A.c. supply circuit breaker
Internal/external electrical supply switch
Windscreen washing and wiping switches
Ballast transfer switches
Generator switches
Side control valve switches
Cabin lights switch
Navigation lights switch
Mooring lights switch
H.P. fuel cock switch

Safety and Marine Equipment

Stowed life jackets - 39 (min.)
Inflatable life rafts (2)
Stowed portable fire extinguishers (2)
Stowed axes (2)
Anchor - 30 lb. Danforth
Floating rope
Signal pistol
Aldis lamp
Bilge pump (2)
Torch
First-aid kit
Door key

Communication and Navigation

Radio - Redifon V.H.F. Type GR289
Compass - Bendix Magnesyn
Standby compass - E2B

NIGHT STANDARD

When equipped for operation by night the SR.N6 can be fitted as for 'daylight' operation but with the following differences.

Furnishings

Passenger seats - 35
Navigator's station - port side forward
Partitioning at commander/
navigator stations
Fixed panels and gangway curtain

Instruments

Rate-of-turn indicator

Communication and Navigation

Radar - Kelvin Hughes Type 17
Intercommunication - Commander/
navigator
Navigator's night lighting
Searchlight - Harley Type 500,
remotely controlled by commander
Gyro compass - Sperry G4D (in place
of Magnesyn type)

Safety Equipment

Stowed life jackets - 37 (min.)
Port windscreen of safety glass with
wiping and washing

performance

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Deceleration	2.9
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Turning performance	2.11
Payload–range	2.12

performance

INTRODUCTION

The performance data given in this section is based on measured results obtained during the trials of production machines, and thus represents achieved performance.

Most of the results were obtained from craft fitted with the continuous - nozzle type of skirt whereas current craft are fitted with an improved combined bag and fingered skirt. The lower part of this skirt is in the form of individual fingers which can move independently like fingers on the hand. Preliminary results from trials of craft equipped with this skirt indicate that the performance, particularly in adverse sea conditions, is superior to that obtained by previous craft. Thus much of the performance data given in this brochure is likely to be pessimistic when applied to craft fitted with the new skirt.

With the exception of engine operating conditions, overwave and gradient capability, the performance is given for calm water and still air conditions, all values being quoted for I.S.A. conditions unless otherwise stated.

No allowance has been made for the effects of taking the engine air from the plenum chamber which has a distinct advantage when operating in cold climates, for de-icing and also minimises the ingress of sand and dust when operating over sand and desert areas. Trials experience indicates that there is a small reduction of performance when the air is taken from the plenum chamber, but this will be less than 10%.

The 'mean operating weight' of 17,300 lb. referred to, subsequently represents a craft equipped to a 'daylight' standard high density passenger role, with a normal A.U.W. of 20,000 lb. operated at a load factor of 75% and with half the fuel used.

performance

THRUST AND DRAG

The total thrust and total drag acting on the craft in still air, calm water and I.S.A. conditions are shown in fig.2.1 as a function of forward speed for the mean operating weight of 17,300 lb.

The drag curve is composed of aerodynamic profile drag, the momentum drag of the air entering the fan intake and the hydrodynamic drag, which includes wave making drag and water wetting drag. The wave making and water wetting drags cause the peak or hump in the drag curve at about 13 knots. With further increase in speed the wave making drag decreases while the other components increase.

The thrust is primarily derived from the propeller, but there are smaller, additional components from the rudder bleed air and the cushion. The reduction in thrust with increase in forward speed is due to the typical fall in propeller thrust.

Where the thrust and drag curves intersect, the craft is in equilibrium and at forward speeds below this intersection the difference between the curves is a measure of the acceleration that can be achieved.

Two thrust curves are given, the lower showing the thrust produced when the engine is operating at the maximum continuous rating of 900 s.h.p. giving a maximum speed of 56 knots. The maximum speed can be increased to 60 knots by using the limited duration maximum rating of the engine.

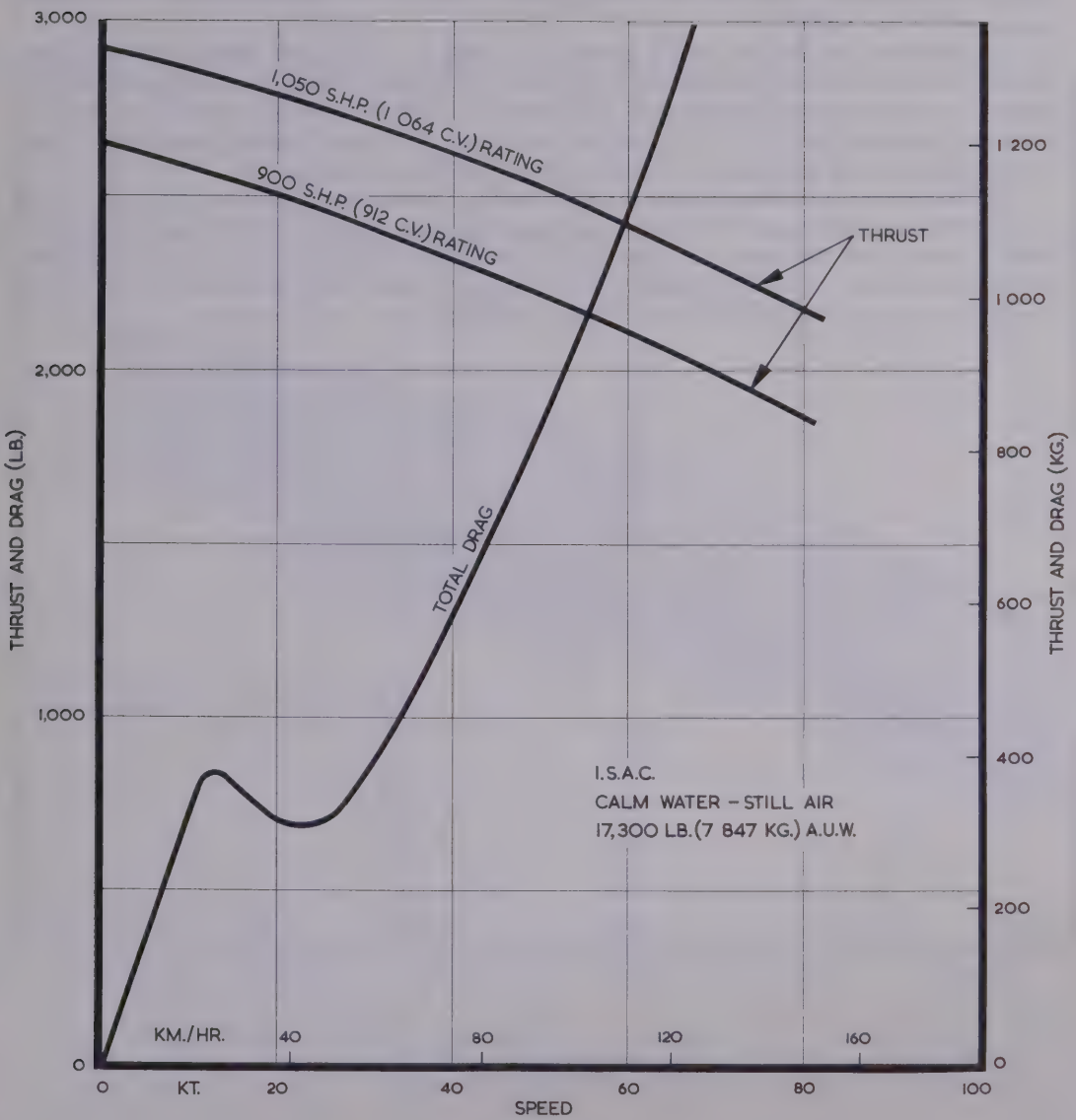

FIG. 2.1 THRUST AND DRAG

performance

FORWARD SPEED

The forward speed performance is shown in fig.2.2 for a range of craft weights in calm water and still air at the maximum and maximum continuous ratings under I.S.A. conditions, together with estimated results for the maximum continuous rating at I.S.A. +15°C.

Experience has shown that apparently identical craft can, under similar conditions, have different performances. This difference can be accentuated by the degree of skirt tailoring applied to a particular craft, the engine condition and the operating trim as well as by varying driver ability. These factors lead to the craft performance being indicated as a band rather than as a single line.

At the mean operating weight of 17,300 lb., and at the optimum trim the craft is capable of an average maximum speed of 56 knots on the maximum continuous engine rating and 60 knots on the maximum engine rating in I.S.A. conditions. When equipped as a 'night' standard craft these speeds will be reduced by one or two knots because of the additional drag caused by the radar scanner.

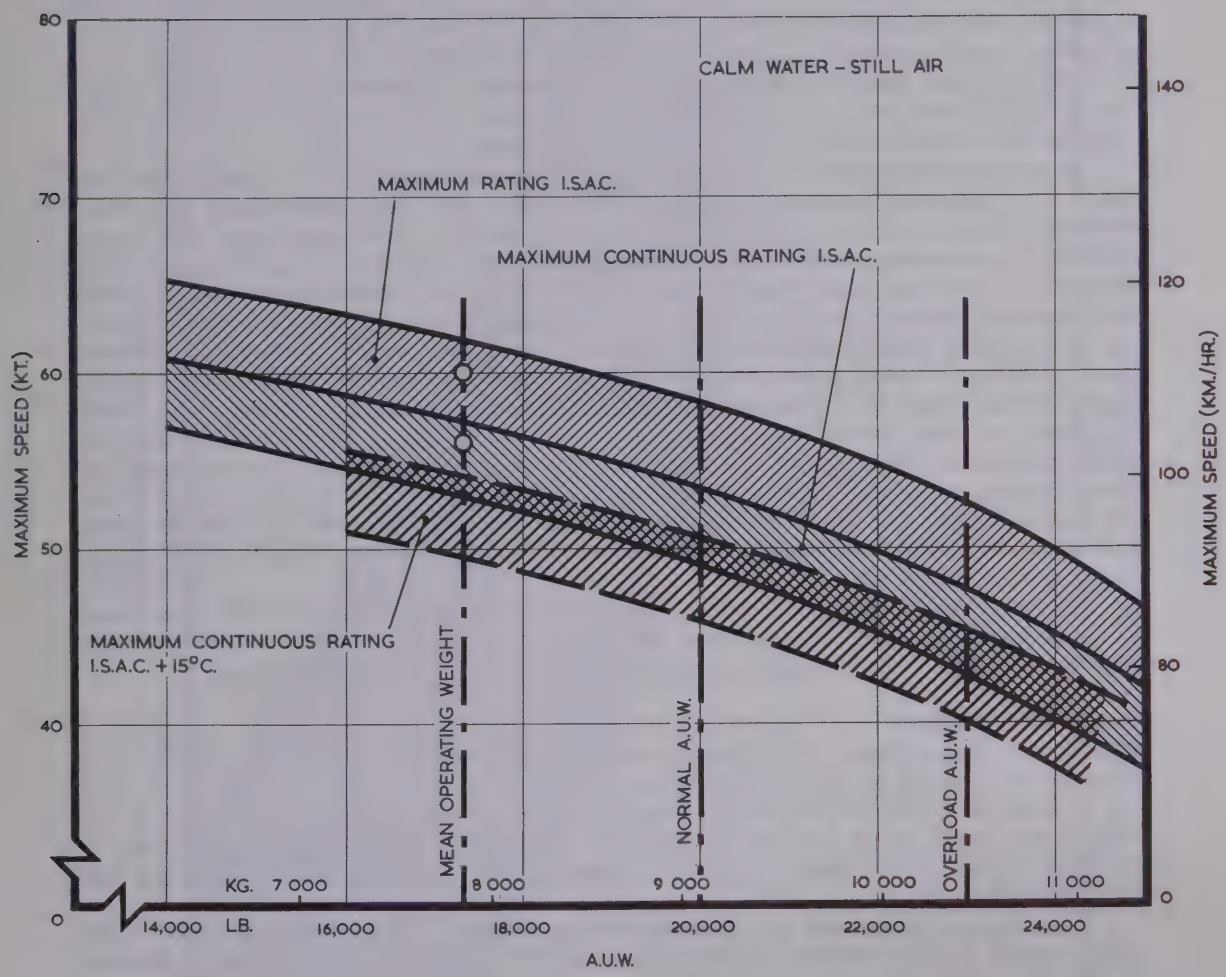

FIG. 2.2 FORWARD SPEED

performance

OVERWAVE

General

During the 9,000 hours of operation that have been accumulated on SR.N6 hovercraft in the last twelve months, detailed information on the craft's seakeeping capability have been obtained from services in the Solent, on the Clyde and in Norway. In addition, SR.N6 hovercraft have operated in the Baltic, the Far East, have made many Channel crossings between Ramsgate and Calais at block speeds of up to 45 knots, and have made a winter crossing of the Irish Sea.

During these activities the craft have frequently negotiated waves of up to ten feet in height and encountered wind speeds of up to 35 knots while maximum wind speeds of the order of 40 knots have been recorded.

It will be appreciated that since the craft performance in any particular sea state is a complex function, not only of wave height and wind speed and their direction relative to the craft, but also of wave length, craft condition and driver ability, it is extremely difficult to predict the overwave performance accurately. Further, it has been noted that in operations across any particular stretch of water the craft has encountered three or four different sea states. This feature of varying sea state is well illustrated by conditions occurring on the Ramsgate to Calais route. With a 25-knot south-westerly wind there may be three to four foot waves approaching from two different directions outside Ramsgate harbour and, with relatively shallow water on the Goodwin Sands a short 'pinnacle' five to six foot sea, depending on the direction of the tide, of about craft length. In mid-Channel the wave height is likely to be eight to ten feet with a length of about two to three times the craft length, and outside Calais due to the shallowing water a short breaking 3 to 3·5 foot sea is encountered very similar to that which occurs off Southsea beach with a south-easterly wind.

Because of these difficulties the SR.N6 sea-keeping capability has been presented in graphical form in which the bands represent the achieved performance and thus include the effects of the parameters in the previous paragraph.

Wave Height – Wind Speed

Figure 2.3 shows plots of maximum wave height, observed from the craft, as a function of wind speed for the Solent area.

No unique curve can be drawn since the maximum wave height is a function not only of the wind speed but also of its direction, which determines the fetch, or distance of water over which the wind is blowing, as well as the direction of the tide relative to the wind.

The figure illustrates the wide variation of maximum wave heights that can occur with a given wind speed. In the Solent a 20-knot wind can create wave heights ranging from 1 to 5 feet which shows how estimates based on limited data can lead to significant errors in the estimation of sea-keeping ability on any particular route.

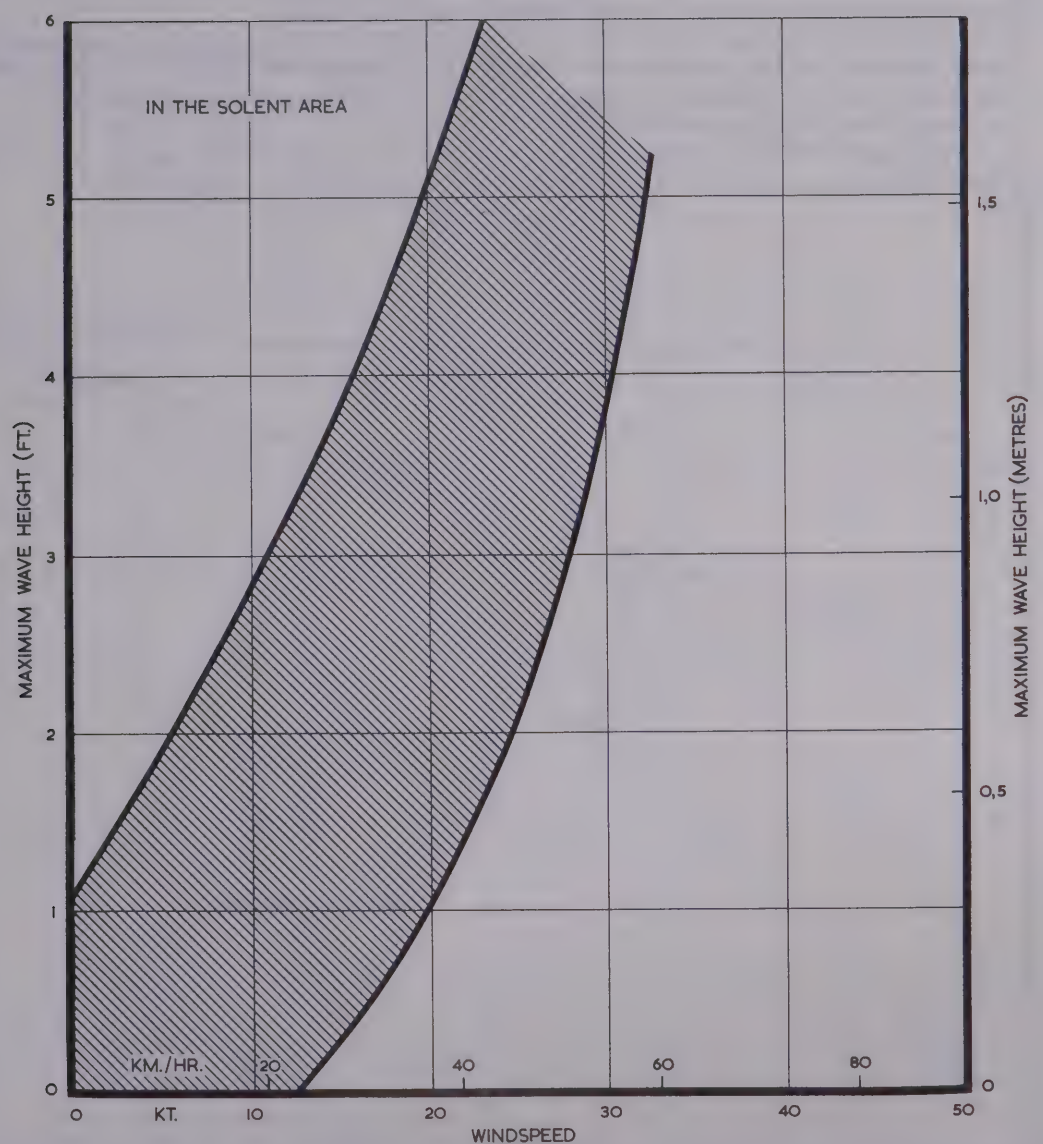

FIG. 2.3 WAVE HEIGHT — WINDSPEED

OVERWAVE

Craft Air Speed – Wind Speed

The air speed of the SR.N6 at maximum continuous or higher powers is given as a function of wind speed for the Solent operations in fig.2.4. Implied in this figure is the range of wave height - wind speed results of fig.2.3.

Distinction has been made between into-wind, down-wind and across-wind results, because of the interchange between aerodynamic and hydrodynamic drags as the wind direction changes. It will be generally possible to attain higher air speeds into wind than down or across wind.

Typically, with a 15-knot wind, measured air speeds in the Solent operations have ranged from about 30 knots down wind to about 60 knots into wind.

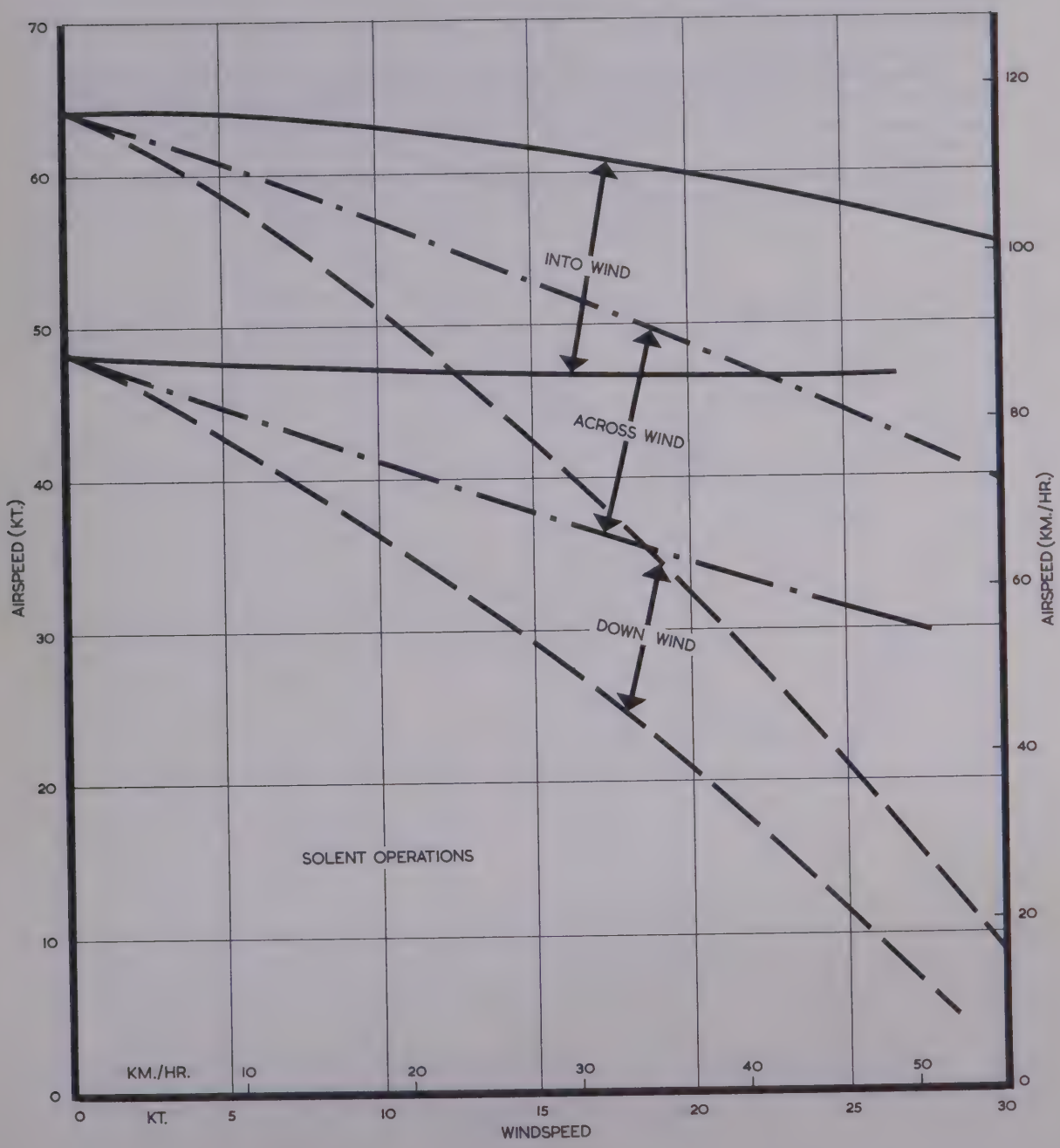

FIG. 2.4 AIRSPEED — WINDSPEED

OVERWAVE

Craft Water Speed – Wind Speed

Figure 2.5 shows the envelopes of craft water speed into, across and down wind as a function of wind speed.

Since for a given water speed the craft drag is higher into wind than down wind and, in addition, the propeller thrust tends to decrease with increase in air speed, the highest water speeds for a given wind speed are usually obtained in the down wind direction.

With a wind speed of 10 knots, craft water speeds in the Solent area have ranged from 35 to about 60 knots.

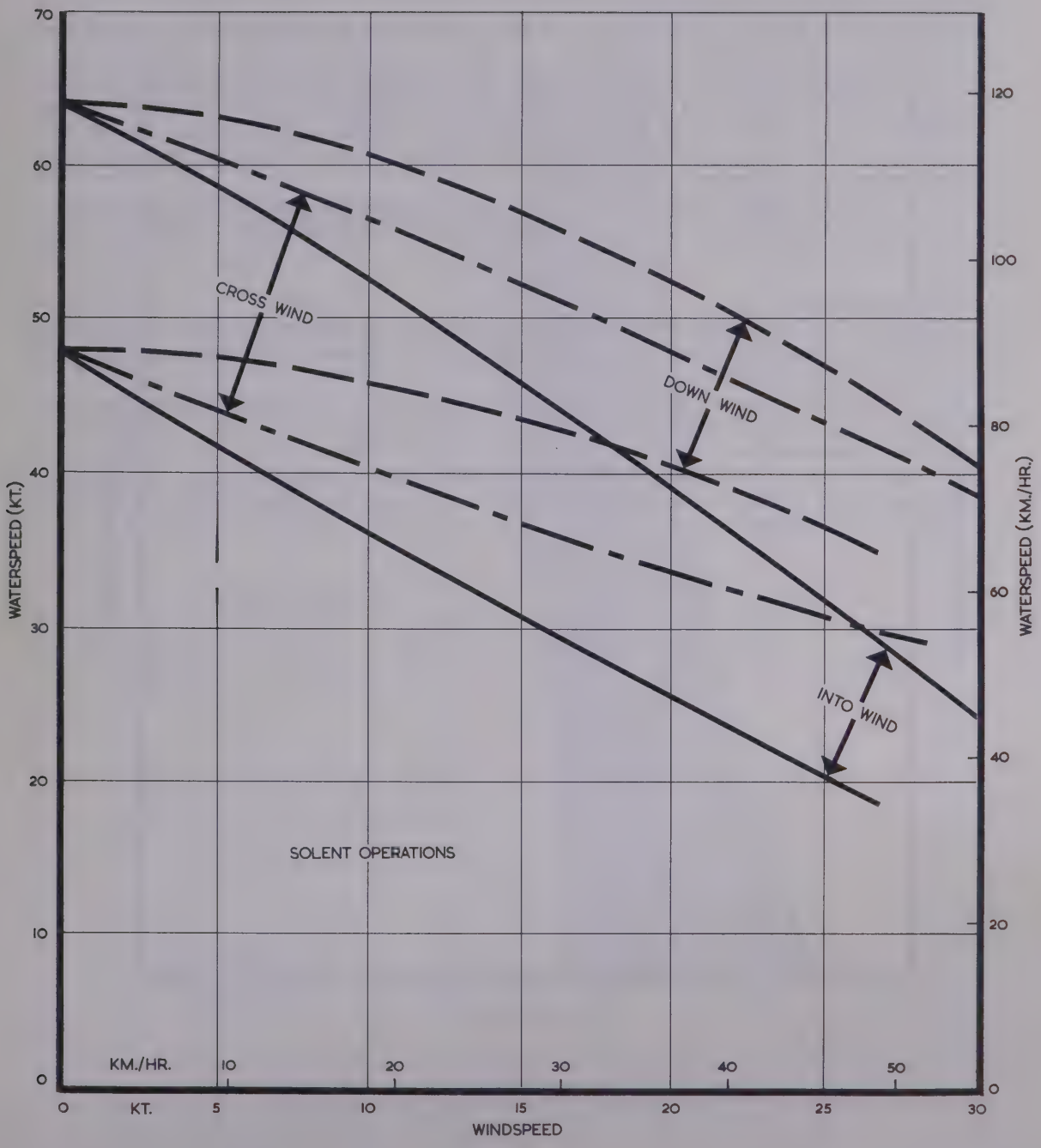

FIG. 2.5 WATERSPEED—WINDSPEED

OVERWAVE

Craft Air Speed – Maximum Wave Height

The envelope of craft air speed into wind as a function of maximum wave height for the Solent area, is given in fig.2.6.

The curves have been compiled from the results of numerous tests on several craft at varying all-up weights, and thus show the effect of driver skill and craft conditions in addition to the scatter arising from varying wave length. It can be seen that with a maximum wave height of 4 feet the likely air speed into wind will lie between 45 - 55 knots for the Solent.

For wave heights below about 5 ft., it has also been found that to a first order, the achieved water speed down or across wind is much the same as the achieved air speed into wind.

Average Service Speeds

In general, water speed is substantially the same as ground speed, thus the curves from fig.2.5 can be used to derive average service speeds and ground speeds as a function of wind speed.

An average service speed of 50 knots with no wind, reducing to 20 knots with a wind of 20 knots would cover most eventualities and would, in the majority of cases, be pessimistic.

As a general rule the service speed corresponds to approximately 90% of the maximum for a given condition and represents a speed readily achievable by the average commander.

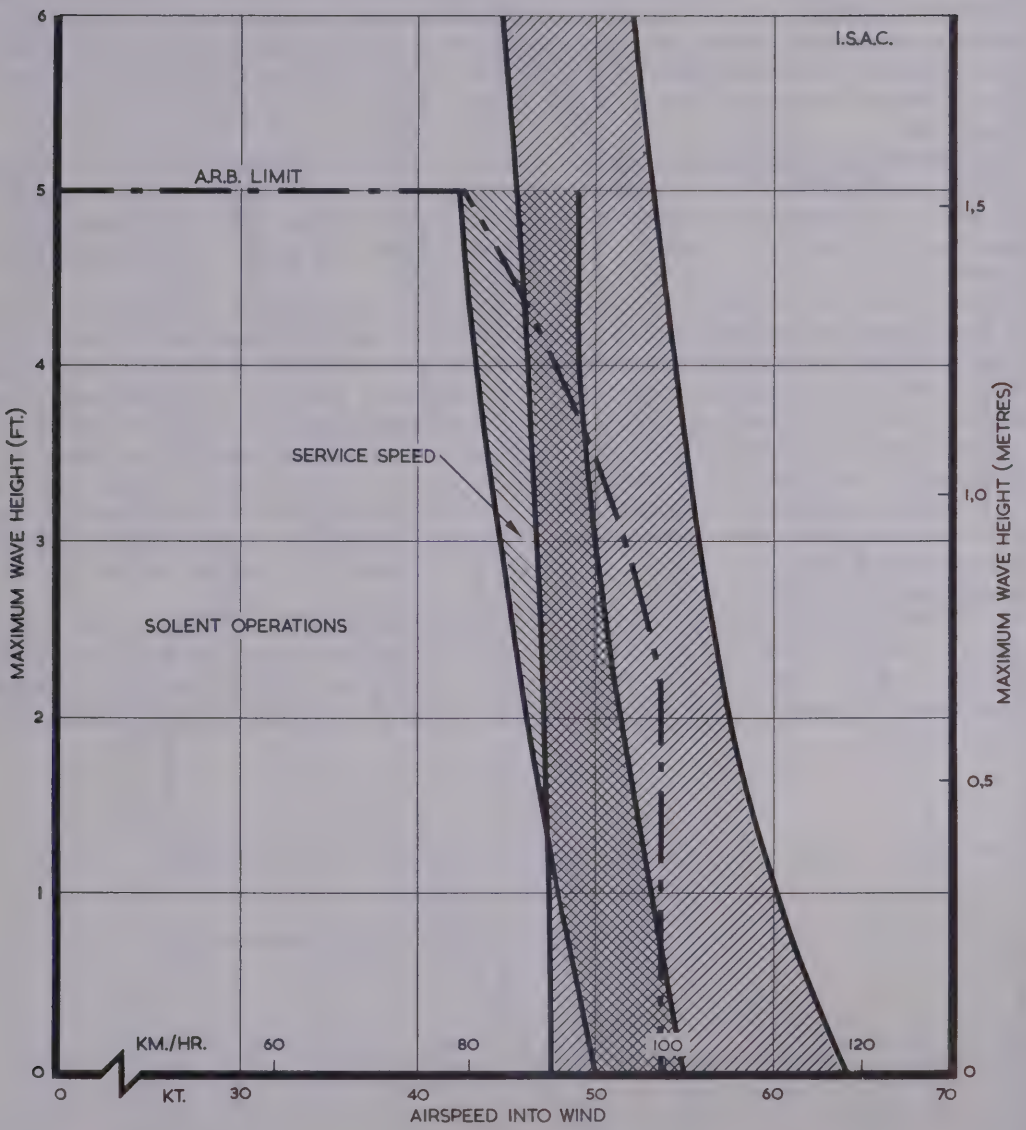

FIG. 2.6 WAVE HEIGHT—AIRSPEED INTO WIND

ENGINE OPERATING CONDITIONS

Figure 2.7 shows the variation of engine output power in I.S.A. conditions with turbine speed for a range of compressor r.p.m., with craft operating conditions superimposed, together with the propeller resonance area. In most conditions the engine would be operating within the area shown and to achieve the performance given in this brochure the compressor would have to be run at 25,400 r.p.m., the cruise or maximum continuous rating of the Gnome engine, unless other conditions are specified.

Operation at higher compressor r.p.m. up to the maximum value of 26,300, corresponding to 1,050 s.h.p. from the engine at the maximum turbine r.p.m. of 20,960 is possible. The engine life will be extended if the operator's schedules are such that they can be achieved, if only occasionally, on power ratings below maximum continuous.

In temperatures above I.S.A. conditions the engine output at a particular compressor speed or throttle setting, falls with increase in temperature, initially by about 0·7% for each degree centigrade rise at the maximum continuous rating up to I.S.A. +9°C. Above this temperature, to maintain the power turbine entry temperature at its limiting maximum continuous rating level of 590°C, the compressor r.p.m. must be progressively reduced, giving a power reduction of about 1·3% referred to the maximum continuous I.S.A. level for each degree centigrade rise. At temperatures below I.S.A. the power output, at a particular compressor speed rises with reduction in temperature. However, to achieve a high engine life it is recommended that for operation in cold climates the engine output power is restricted to the I.S.A. level.

At the mean operating weight of 17,300 lb. the craft will 'lift off' at a turbine speed of about 9,600 r.p.m. The normal operating turbine speed at this weight will be about 17,000 r.p.m. although other weights and varying ambient conditions may require speeds ranging from say 15,000 r.p.m. up to the maximum of 20,960 r.p.m.

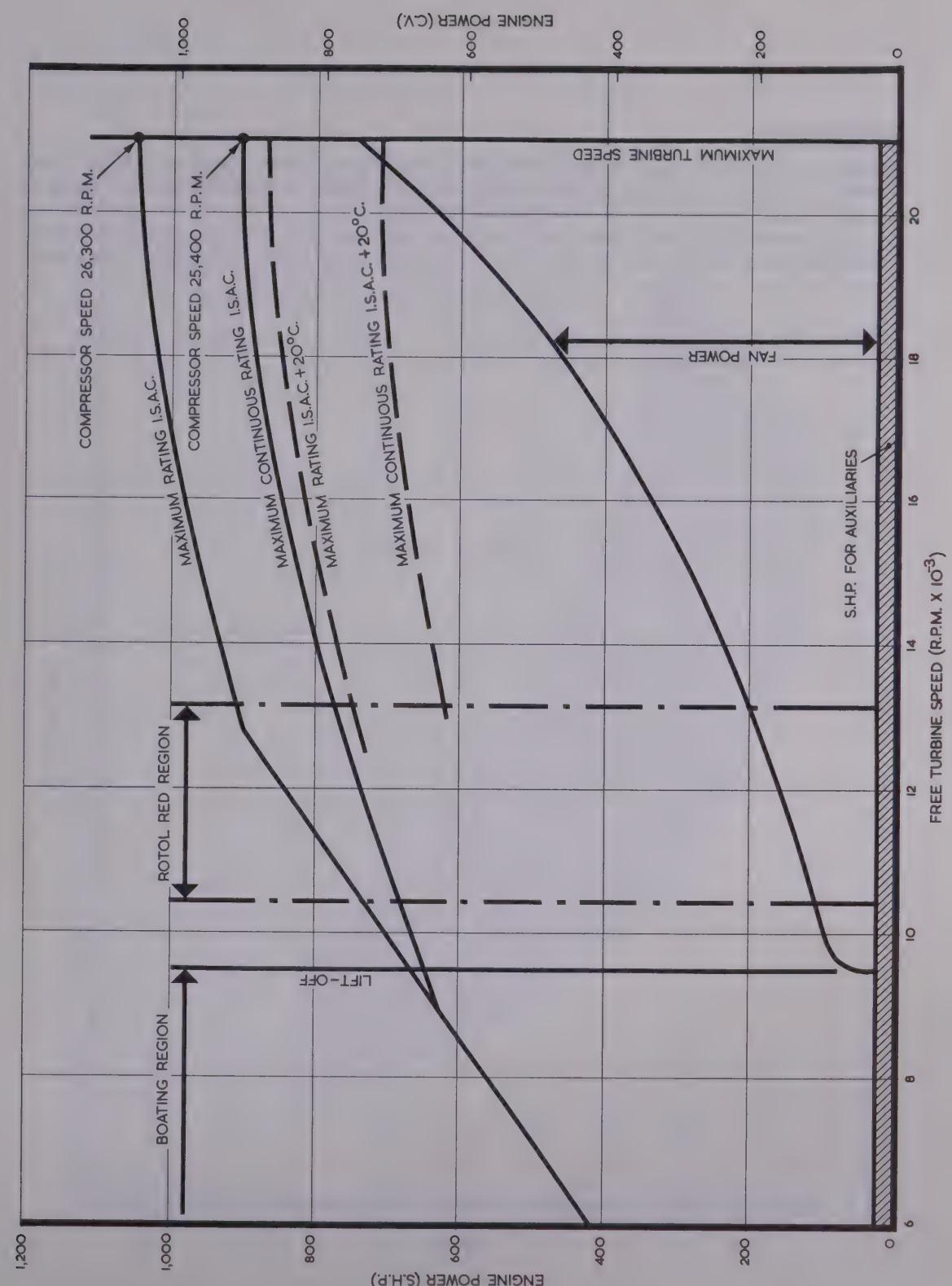

FIG. 2.7 ENGINE OPERATING CONDITIONS

ACCELERATION

The curve given in fig.2.8 shows the time to reach a given speed in I.S.A. calm water, still air conditions when using the maximum continuous power rating at craft weights of between 14,000 and 20,000 lb.

To reach a cruising speed of 50 knots at the mean operating weight of 17,300 lb. will take 38 seconds. However, at very low operating weights this time can be reduced to less than 25 seconds.

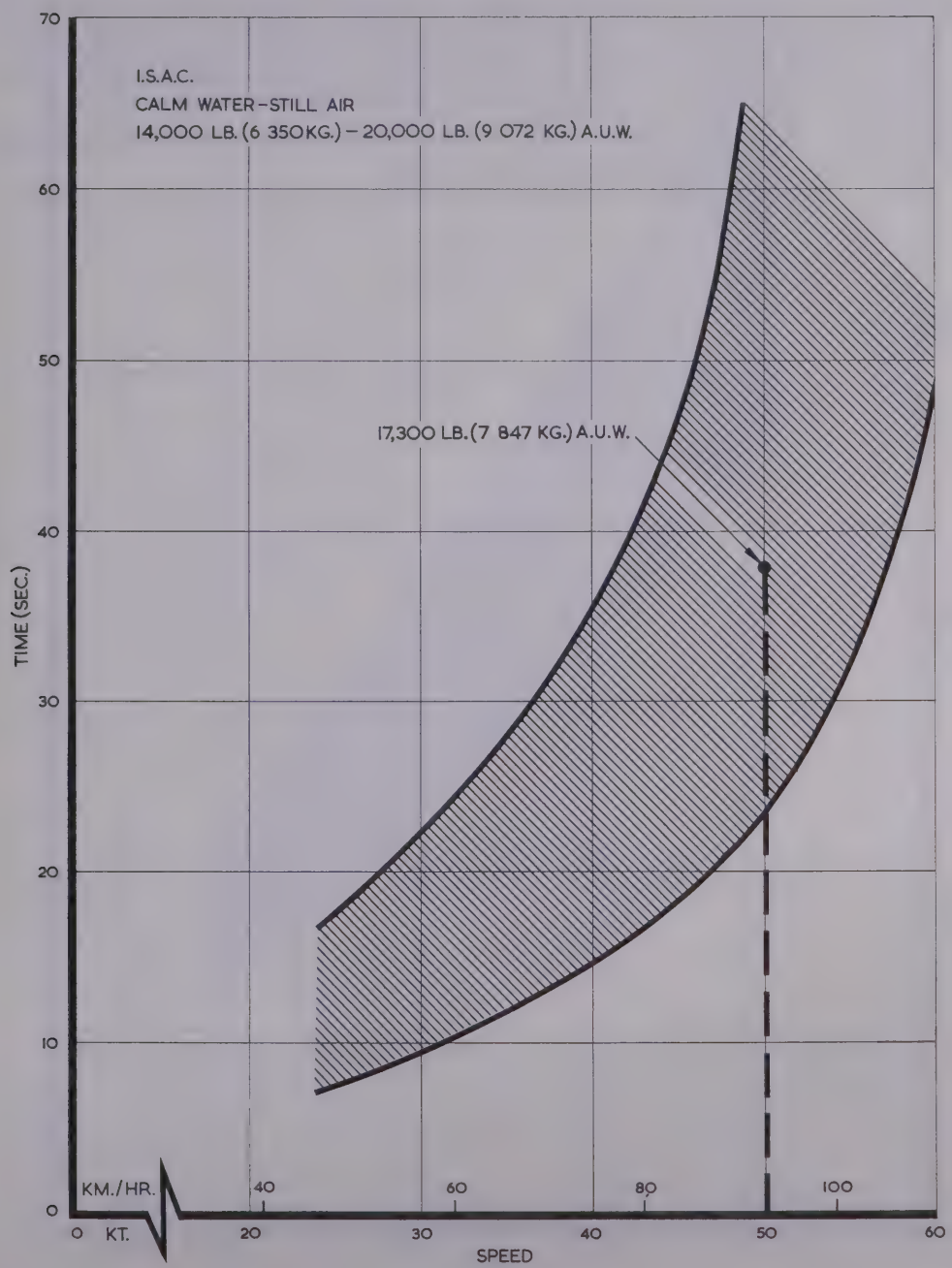

FIG. 2.8 ACCELERATION

DECELERATION

Figure 2.9 shows the distance required to decelerate from a given forward speed using the normal procedure. This consists of using propeller reverse thrust until the speed has been reduced to about 30 knots and then gently closing the throttle, with the propeller still in negative pitch, to allow the craft to settle on the water.

Using this technique the braking distance from a speed of 50 knots in still air at a weight of 17,300 lb. is 275 yards.

In an emergency the throttle could be closed immediately reducing the stopping distance to less than 150 yards.

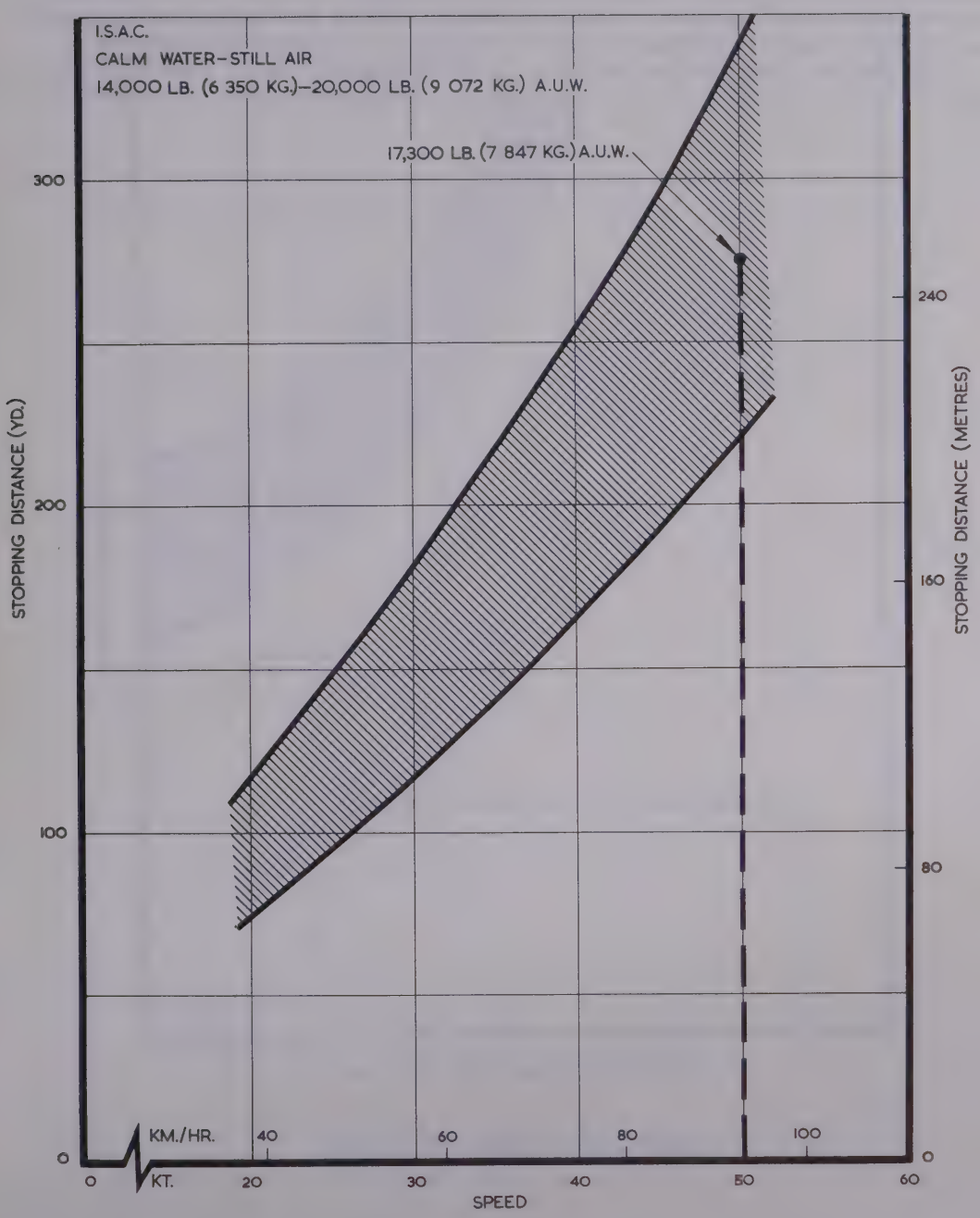

FIG. 2.9 DECELERATION

GRADIENT PERFORMANCE

The calculated gradient performance using the maximum continuous power rating is shown in fig.2.10 for a range of initial craft speeds at the start of a gradient of length 100 yards. The point at which the initial speed is zero indicates the gradient on which the craft can remain stationary under I.S.A. conditions in still air.

All SR.N6 craft have negotiated a 1 in 10 slipway from a standing start at weights up to 17,300 lb. and, with some initial speed, at weights up to 25,000 lb.

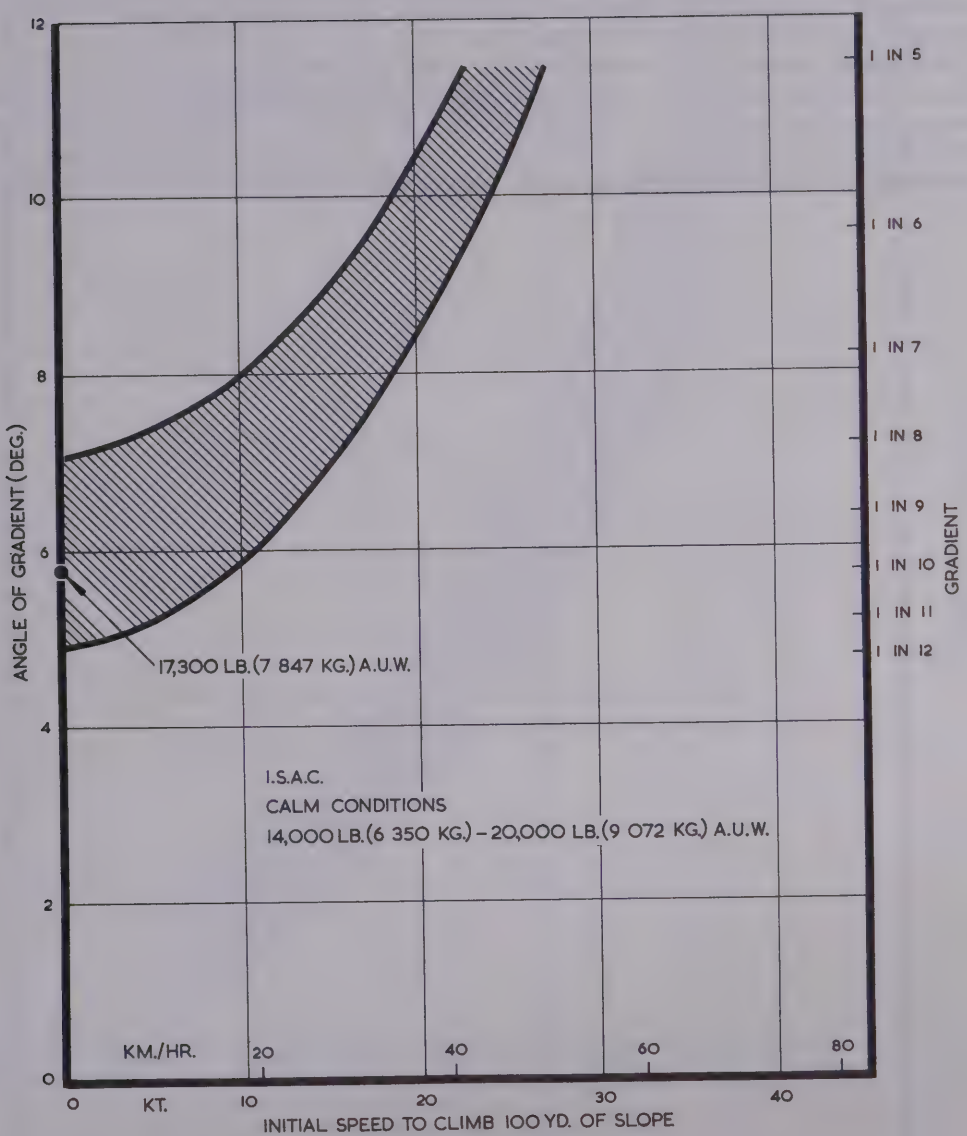

FIG. 2.10 GRADIENT PERFORMANCE

TURNING

Figure 2.11 illustrates the craft's normal turning radius as a function of entry speed for a range of weights when using the maximum continuous power rating.

This manoeuvre is accomplished by yawing and rolling the craft to produce the necessary moment and sideforce and at the mean weight of 17,300 lb. gives a normal radius of turn of 385 yards at an entry speed of 40 knots.

Tighter turns can be made by increasing the roll angle so that part of the skirt becomes immersed in the water thus giving a hydrodynamic force. Typically this can reduce the radius given above to about 250 yards. However, experience has shown that the majority of commanders prefer to decelerate before entering a turn particularly if the turn is to be made across wind from a down wind heading.

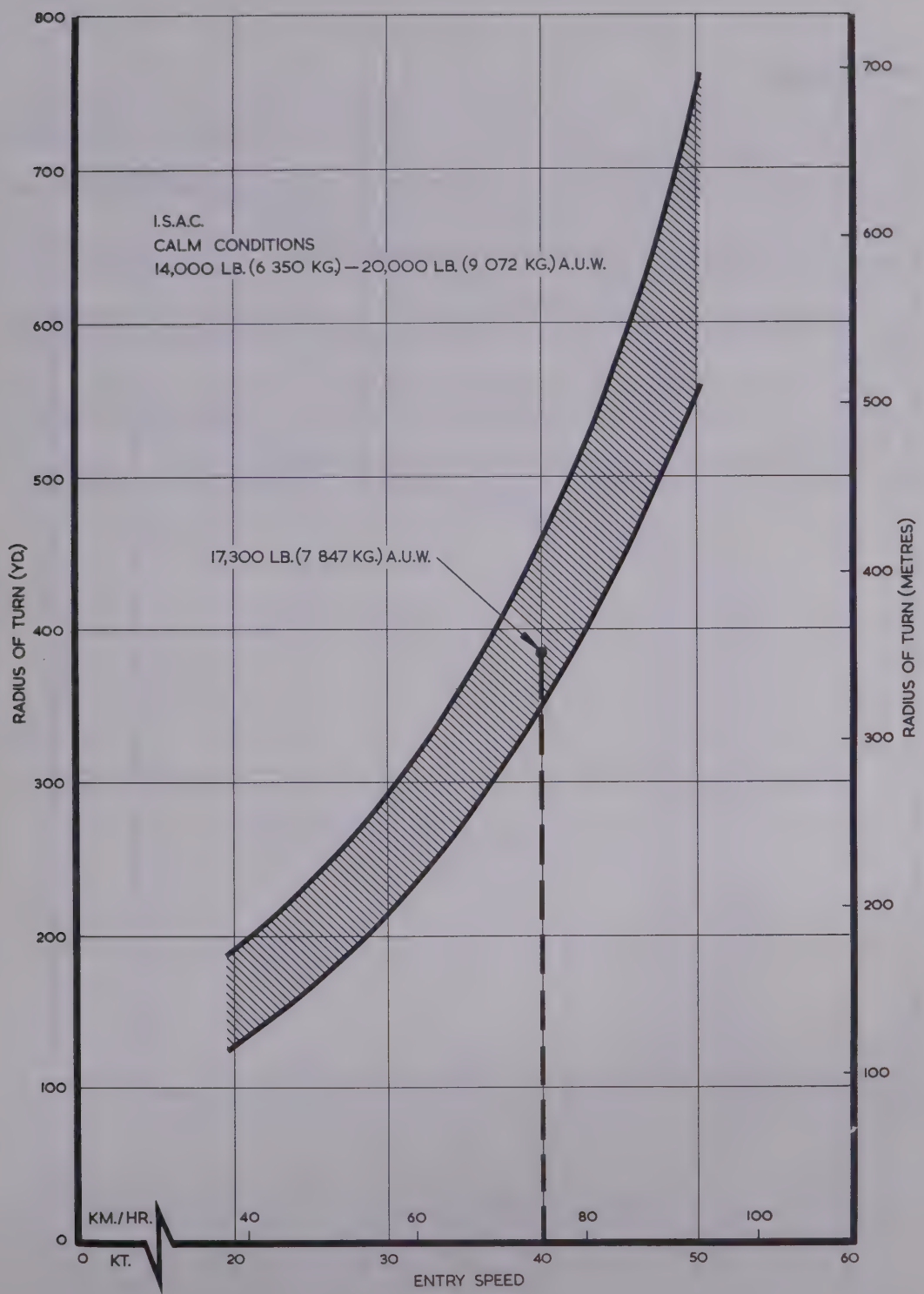

FIG. 2.11 TURNING PERFORMANCE

performance

PAYLOAD RANGE

Figure 2.12 shows the calm water, still air payload - range performance at take-off A.U.Ws of 20,000 lb. and 23,000 lb. corresponding to normal maximum and overhead A.U.Ws respectively.

The maximum internal fuel load is 2,120 lb. or 265 Imperial gallons of kerosene giving an endurance of 3·63 hours at the 900 s.h.p. rating.

At the normal maximum A.U.W. of 20,000 with a maximum fuel load the average cruising speed is about 53 knots, giving a range of approximately 190 n. miles with a 6,780 lb. payload.

With maximum fuel at the overhead A.U.W. of 23,000 lb. the average cruising speed is about 48 knots, giving a range of approximately 175 n. miles with a 9,780 lb. payload.

By replacing payload with extra fuel tankage the absolute ferrying range could be increased to about 1,140 n. miles in ideal conditions, assuming a take-off A.U.W. of 23,000 lb.

In adverse weather conditions the endurance will be the same as in ideal conditions, but the range will be reduced in proportion to the ground speed achieved.

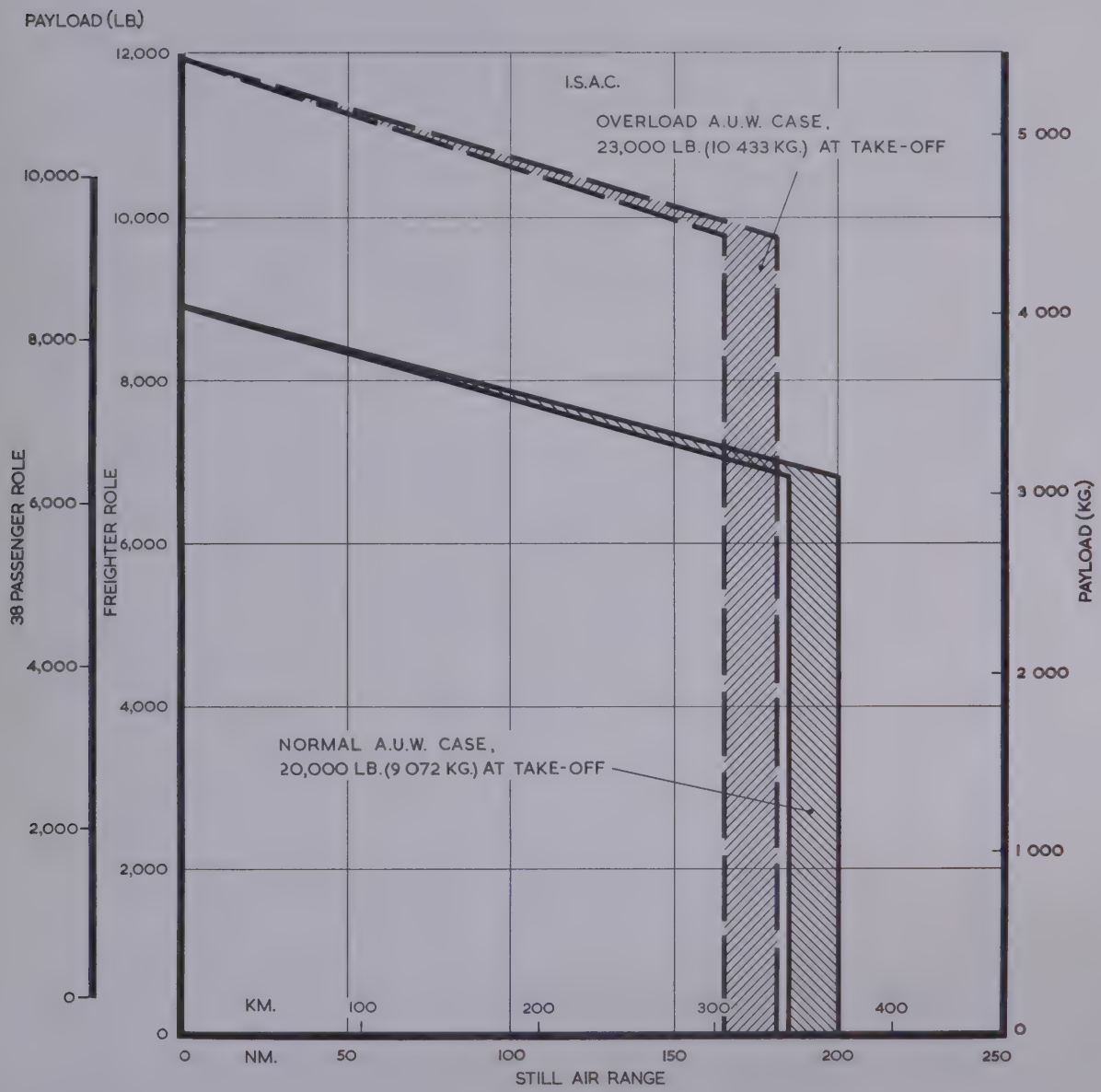

FIG. 2.12 PAYLOAD-RANGE

licensing

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Present procedure in the United Kingdom	3.1
Types of permit that are currently issued	3.1
Documentation provided	3.2
Steps to be taken by an operator	3.2

licensing

The following is an extract from British Hovercraft Corporation Ltd. Publication SP.1054 in which guidance is given on the procedure for the certification of hovercraft.

PRESENT GENERAL PROCEDURE IN THE UNITED KINGDOM

Until such time as legislation is enacted hovercraft are covered by appropriate existing transport regulations. For over-water and coastal operations, the Ministry of Aviation has assumed responsibility for purposes of certification and the Air Registration Board machinery is used. The Ministry of Aviation, in consultation with the Board of Trade, Marine Division, issue the necessary permits.

Seagoing hovercraft are treated as if they were power-driven vessels for the purposes of the international rules for collision avoidance at sea. It is hoped that international agreement on this point can be reached. Currently, general notification of the operation of hovercraft in a given area within British Territorial waters is given by means of a Notice to Mariners issued by the Board of Trade.

In general, British hovercraft are designed to the British Civil Air Cushion Vehicle Safety Requirements (B.C.A.C.V.S.R.) which have been agreed by both A.R.B. and the hovercraft industry. When they are satisfied that a craft complies with the appropriate standards of safety, to stated operational limitations, A.R.B. signify their approval of the craft by the issue of a Certificate of Construction and Performance (C.C.P.). Under A.R.B. procedures design and inspection authority can be delegated to a responsible, technical and manufacturing organization and the British Hovercraft Corporation Ltd. (B.H.C.) carries this full approval.

TYPES OF PERMIT THAT ARE CURRENTLY ISSUED

Development permit

On completion of the first craft B.H.C. apply to the Ministry of Aviation for a permit to operate on development trials in a defined testing area. No performance restrictions are placed on the craft by the Ministry and the craft is operated in accordance with the restrictions imposed by the Certificate for Flight Trials issued by B.H.C.

Demonstration permit

As development progresses, application is made for the permit to be extended to cover demonstrations to potential customers and visitors to the Company. This permit will define the standard of safety equipment required by the Ministry of Aviation and Board of Trade and performance limitations will be appropriate to the development stage reached. The technical limitations of a demonstration permit approximate to those which are applicable to a fare paying passenger operating permit but of course only apply to craft operated and maintained by B.H.C. personnel in a defined area. All production craft receive a demonstration permit prior to their despatch to an operator.

B.H.C. apply for a permit to carry fare paying passengers on a specific route as soon as a Certificate of Construction and Performance has been granted for the prototype. A regular fare paying passenger operation can be carried out under this permit and the limitations in the initial C.C.P. may later be replaced as the accumulation of the trials and operating experience show this to be possible. Thereafter the operator would be expected to obtain his own fare paying passenger permit for the particular routes on which he wishes to operate.

licensing

In the United Kingdom fare paying passenger permits are associated with an operating route and in obtaining the permit consideration is given by both the Board of Trade and the Ministry of Aviation to the sea conditions of the area, the communications required for normal operation, the life-saving equipment and the availability of rescue services. Consequently a completely open permit irrespective of the area of operation is not given at the present time.

DOCUMENTATION WHICH IS PROVIDED WITH B.H.C. HOVERCRAFT

The following documentation is included in the sale of a B.H.C. hovercraft :-

(a) Certificates of Design/Construction and Performance signed by fully approved B.H.C. personnel.

(b) A typical fare paying passenger permit for the type obtained from the Ministry of Aviation. This permit will indicate the limitations the operator may expect to be imposed.

(c) Certificate of Construction and Performance issued by A.R.B.

(d) The vehicle log book containing log cards of all significant components of the craft, such as engines, fans, propellers and other equipment.

(e) The build standard of the craft, including the approved modification schedule.

(f) A report covering the production tests of the craft to the agreed test schedule together with a certificate of flight trials.

(g) A weighing report covering the detailed weight and C.G. location of the craft.

(h) An Operator's Handbook, a Workshop Manual, and a Spares Catalogue.

It is assumed that prior to delivery of the craft an operator would have at least one pilot and possibly two engineers trained in the operation and maintenance of the craft. In initial operations these would be backed by a B.H.C. Service Engineer. B.H.C. would issue a Certificate of Competency for these personnel when they had been trained and had gathered adequate experience.

It is recommended that pilots chosen for training should have substantial marine experience together with a rudimentary knowledge of aerodynamics and aircraft control systems.

STEPS TO BE TAKEN BY AN OPERATOR

Prior to taking delivery of the craft an operator should contact the following authorities in his own country.

The equivalent of the British Ministry of Aviation or Transport to establish acceptance of British permits and certification.

The public authorities involved on a particular route.

Insurance companies.

These authorities may require an independent contact with the corresponding British authorities regarding the operation of the craft. If this is required we would recommend that they make contact with the following :-

The Operations Officer, Directorate of Flight Safety, Ministry of Aviation, Shell Mex House, Strand, London, W.C.2.

The Nautical Surveyor, Marine Safety Branch, Marine Division, Board of Trade, Surrey House, Southwark Street, London, S.E.1.

The Chief Technical Officer, Air Registration Board, Brabazon House, Redhill, Surrey.

At the present time the Operations Officer is Mr. A.O. Jones, the Nautical Surveyor is Capt. J. Batchelor and the Chief Technical Officer is Mr. W. Tye.

For general information it may be noted that the following Harbour Authorities and Town Councils are among those who have the most experience of demonstration and fare paying passenger hovercraft operations.

Harbour Authorities	Town Councils
Cowes, Isle of Wight	Ryde, Isle of Wight
Portsmouth	Cowes, Isle of Wight
Southampton	Portsmouth
Dartmouth	Weston-Super-Mare
Montreal	Penarth, South Wales

The documents contained in this guide are samples of the documentation that will be included with the craft. It has proved more than adequate for obtaining fare paying passenger permits and should form a very good basis for initial discussions with your national and local authorities.

The items on which there is likely to be the most discussion are the life-saving and emergency equipment. In this connection we would recommend that operators should familiarize themselves thoroughly with the section in the Operator's Handbook covering emergency procedures. This indicates the limits under which the craft may be anchored and towed, the procedures in the event of fire, together with all the normal operating techniques.

It would be advisable to obtain from the Post Office or appropriate authorities the radio frequencies that you will be allowed to use. In general it is necessary to have a base station at least at one end of the route and telephone communication between the bases. In addition, data should be collected on local coastguard stations and likely emergency beaching areas.

engineering

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engineering

GENERAL DESCRIPTION

The craft is of all-metal construction, the majority of the structure being constructed from light-alloy material which has been cleaned and primed before assembly as a protection against corrosion. The structure is also painted inside and out with an epoxy-based paint. The main load carrying structure comprises two girders which extend the full length of the craft and are braced by the aft bulkhead of the cabin. Buoyancy tanks, sub-divided into twelve watertight compartments, are located outboard of the two girders and also between the girders at the aft end of the craft, form a platform; a plenum chamber is around the periphery. The passenger cabin is set forward into the plenum chamber and buoyancy tanks, the floor of the cabin forming the base of the platform. As the cabin is below the water-line when the craft is not cushion borne, it also contributes to the buoyancy of the craft. For added safety, the cabin floor is double skinned, the intervening space being filled with foam plastic. Access to the cabin is by a combined bow loading door and ramp. The wide dorsal pod on the cabin roof structure contains the life raft. Immediately aft of the propeller is the tail unit comprising twin fins with rudders for directional control and two all-moving tailplanes for longitudinal trimming whilst side control ports using plenum chamber air further assist yaw control. When the craft is at rest on the land, it is supported on six landing pads which prevent damage to the undersurface of the buoyancy tanks and also prevent the skirts becoming trapped. Four slinging points are provided which, together with suitable ground equipment, allow the craft to be lifted for skirt and underside maintenance. Points are also provided at both the front and rear of the craft to permit the attachment of jacking beams. Twin towing eyes are provided at the forward end of the centre section. Forward, aft and athwartship walkways give ready access to all major components. The side decking can be readily detached, thus reducing the overall width to 9 ft. (2,74 m.) and enabling the craft to be more easily transported by road or air.

Synthetic rubber coated fabric skirts extend round the periphery of the plenum chamber and are suspended from outriggers mounted on the buoyancy tanks. The skirts are constructed in segments to facilitate replacement and are attached to the structure by simple piano hinge type fittings. Stability of the craft is improved by keels in cruciform arrangement in the air cushion contained by the skirts.

The integrated lift/propulsion system employs a single Bristol Siddeley 'Marine Gnome' gas turbine engine coupled to a centrifugal lifting fan and a variable pitch propeller. The drive to the propeller is through two reduction gearboxes; the second gearbox also drives the lift fan through a bevel gear. A dual function lubrication and hydraulic system lubricates the engine and transmission gearboxes and also supplies oil to operate the propeller pitch mechanism, skirt lifting and side control port jacks. The air cushion is generated by the fan which is located in the plenum chamber, aft of the cabin.

The main fuel tank is sited behind the cabin and immediately below the engine, and is of the flexible bag type. A single low pressure, electrically-driven pump delivers fuel to the engine high pressure pump. Both the engine and the fuel system are accessible for maintenance from deck level and a single refuelling point is located on the port side of the craft at cabin roof level.

Conventional 28-volt, d.c. power is supplied by a Westinghouse generator, giving an output of 140 amps at 30-volts d.c. On craft without air conditioning, the generator is belt-driven from the No.1 gearbox and on those with air conditioning is driven from a forward accessories gearbox which is driven by a shaft from the No.1 gearbox. Secondary generation giving 400 c/s 3-phase a.c. at 115 volts is from an inverter situated in the starboard bow compartment. A 24-volt battery is located in the bow compartment and an external supply socket is also provided.

The commander's station is located forward at the starboard side of the cabin. The seat is on a raised platform providing excellent all-round vision. Two instrument panels, both situated in front of the commander, provide a simple presentation of all essential data, such as compass heading, air speed, propeller-pitch and power turbine r.p.m. indicators, together with fuel and oil contents gauges and appropriate warning lights covering fire, low oil pressure, engine over-heating and generator failure. Auxiliary controls are conveniently at hand for fuel ballast transfer, windscreen washing, wiping and heating, cabin lighting, navigation lights, fire extinguishing etc.

Two all-moving tailplanes, which are used for in-flight longitudinal trimming, are operated by a lever at the right-hand side of the commander's seat. The primary means of longitudinally trimming the craft is by a switch operated fuel-ballast transfer system containing 45 gallons (204,6 litres) of fuel which is also used as a reserve fuel supply.

Two rudders are used for directional control and are controlled by an aircraft-type, foot-operated, rudder bar. The rudders are supplemented by electrically-controlled, hydraulic operated, fore and aft side control ports that use air bled from the plenum chamber.

Skirt lifting at the four 'corners' of the craft is operated by hydraulic jacks controlled by a 'joystick' type control column situated between the commander's seat and the lower instrument panel; this control provides pitch and roll to assist manoeuvring.

The engine is controlled by a twist-grip mounted on the propeller pitch control lever which is also at the commander's right hand, thus providing single handed control of hover height and speed. Movement of the lever forward in conjunction with opening the throttle accelerates the craft.

STRUCTURE

The structure is largely of light-alloy material and is protected against corrosion by cleaning and etch priming before assembly. After assembly, the structure is painted inside and out with several coats of epoxy-based paint.

The hull of the craft is in three sections, a centre section and two outboard sections. The centre section comprises the passenger cabin fuel tank and lifting fan bays together with the rear platform on which is mounted the tail unit. In way of the lifting fan the main bending beams are of Warren girder construction to allow the fan to supply air to the side and forward skirts. The forward portion of the tail unit platform forms a plenum chamber which feeds air to the aft skirt and to the longitudinal stability keel; the aft portion of the tail unit is closed structure and forms a buoyancy chamber.

Each of the port and starboard outboard sections consists of a buoyancy chamber which is attached to the main bending beam and runs the full length of the craft. A series of outriggers mounted on the buoyancy chamber support the decking and the outer skirts, the inner skirts are suspended from the outer wall of the buoyancy tank.

To maintain buoyancy in the event of damage the tanks are divided into water-tight compartments. Additional buoyancy is provided by the cabin, the floor of which is below the waterline. The floor is a sandwich of two thin light-alloy skins glued to a 'Plasticell' (foamed plastic) core. The upper surface of the floor is re-inforced by a 1/32 in. thick Ferobestos sheet and, if required, an additional covering of 'Lionide' can be provided.

Entrance to the cabin is by a bow door which is divided horizontally into two hinged sections which open in opposite directions; the lower section also forms a loading ramp.

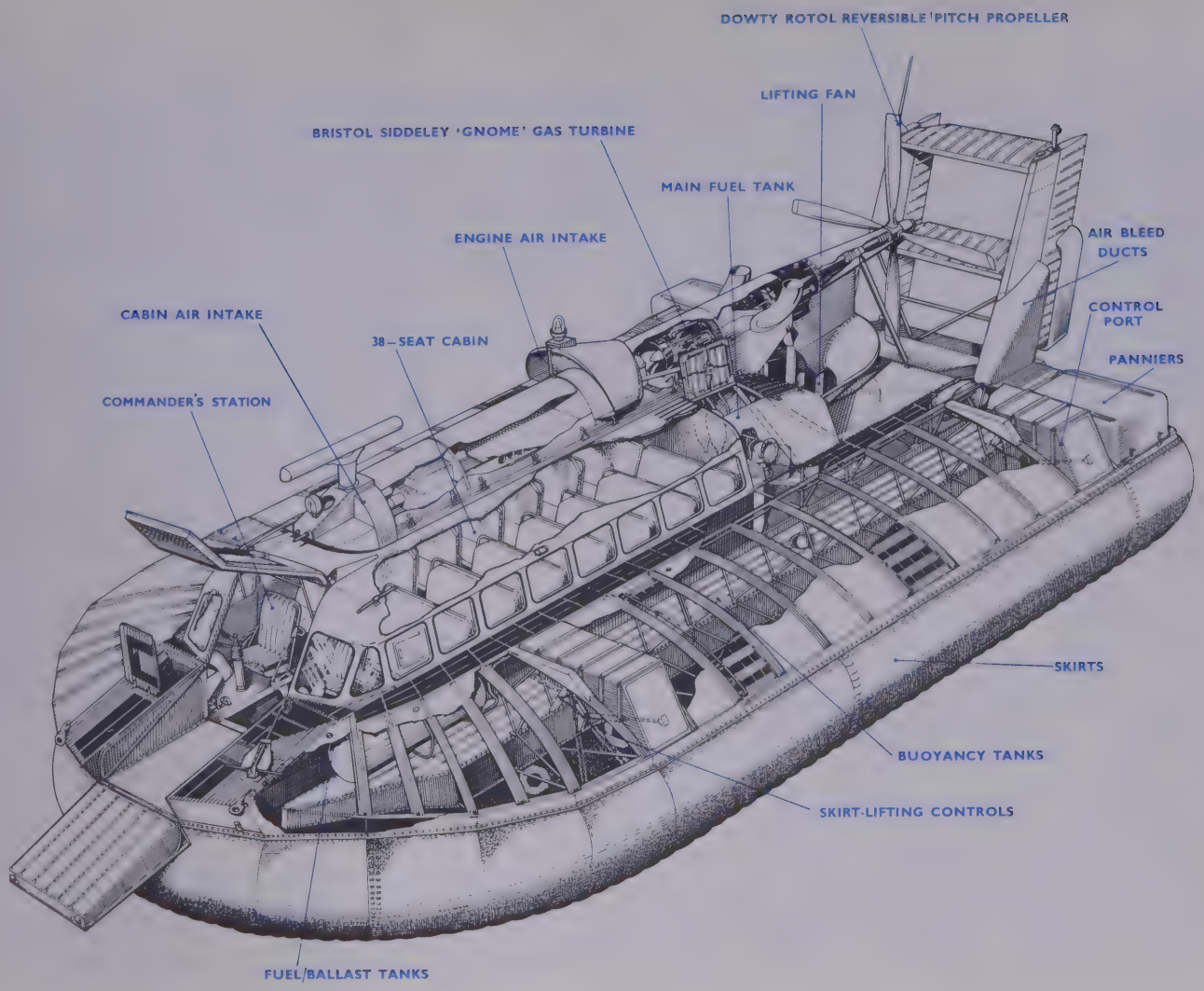

FIG. 4.1 CUT-AWAY VIEW OF SR.N6

Aft of the cabin is the fuel tank bay and above this is a tubular structure that supports the engine, reduction gearboxes and propeller. Immediately aft of the fuel tank is the lifting fan intake, which is of glass fibre, and on the port and starboard sides of this are the intakes for the engine air supply which is supplemented by a second intake on the cabin roof.

Forward of the engine and on the cabin roof is a dorsal pod in the forward end of which is an air intake for the cabin air conditioning system; the pod also houses two inflatable life rafts.

At the extreme aft end of the craft is a conventional aircraft-type trim tail unit having twin rudders and twin all-moving tail planes. To improve rudder response at low speeds air is bled from the aft plenum chamber and ducted across the rudders.

The flexible trunks and stability keels extend four feet below the solid structure and are made from a highly durable and abrasion-resistant material consisting of nylon fabric coated with a P.V.C. and nitrile rubber composition. The trunks extend round the periphery of the craft and are made up of inner and outer skirts which are shaped to direct the air from the lifting fan inboard. The stability keels are inflated by air ducted through the structure, the duct for the longitudinal keel being immediately aft of the fan; for the lateral keels the duct is taken through the side buoyancy tanks. The skirts are attached to the structure by 'piano type' hinges having withdrawable pins and are constructed in sections which are bolted together so that in the event of damage they can be easily replaced.

Partitions attached to the inner and outer skirts at intervals round the peripheral trunking preserve the shape and also act as splitters; the width of the slot at the base of the trunks is maintained by short lengths of chain.

A single oil tank mounted forward of the engine provides a common supply for lubricating the engine and transmission and also for supplying pressure oil to the propeller pitch changing gear, the skirt lifting jacks and the yaw control port jacks.

Both the engine and the transmission are readily accessible for maintenance and can easily be changed as the entire power unit is supported on only four main points.

POWER PLANT AND TRANSMISSION

The SR.N6 is powered by a Bristol Siddeley 'Marine Gnome' free-turbine engine having a maximum continuous rating of 900 s.h.p. and a maximum five-minute rating of 1,050 s.h.p. The engine is a marinised version of the well known helicopter power unit from which it differs in that it has a simplified fuel control system and additional protection against salt-water corrosion. An alternative power unit is the General Electric L.M.100.

The engine drives a 9 ft. diameter, four-bladed, reversible-pitch propeller for providing thrust and braking and a 7 ft. diameter, twelve-bladed centrifugal fan of B.H.C. design for supplying cushion air. The transmission is of the integrated type, in which the drives to the fan and propeller are geared together, the division of power being determined by the pitch setting of the propeller. Power is transmitted to the propeller and fan through two reduction gearboxes. The first gearbox, which is mounted on the aft end of the engine, reduces the speed and also provides drives for such auxiliaries as oil pressure and scavenge pumps and an electrical generator.

On craft that are fitted with air conditioning equipment the electric generator, together with an air compressor, is mounted on the aft end of the dorsal pod, and these are driven by a shaft from the main gearbox, through an auxiliary gearbox.

A shaft from the first reduction gearbox drives the propeller through a single stage reduction gear in the second gearbox, which also contains a spiral bevel reduction gear to drive the fan. An auxiliary gear train drives hydraulic pumps for propeller pitch change, side control and skirt actuation. The gearbox casing extends aft to support the propeller shaft and also contains the propeller pitch change mechanism.

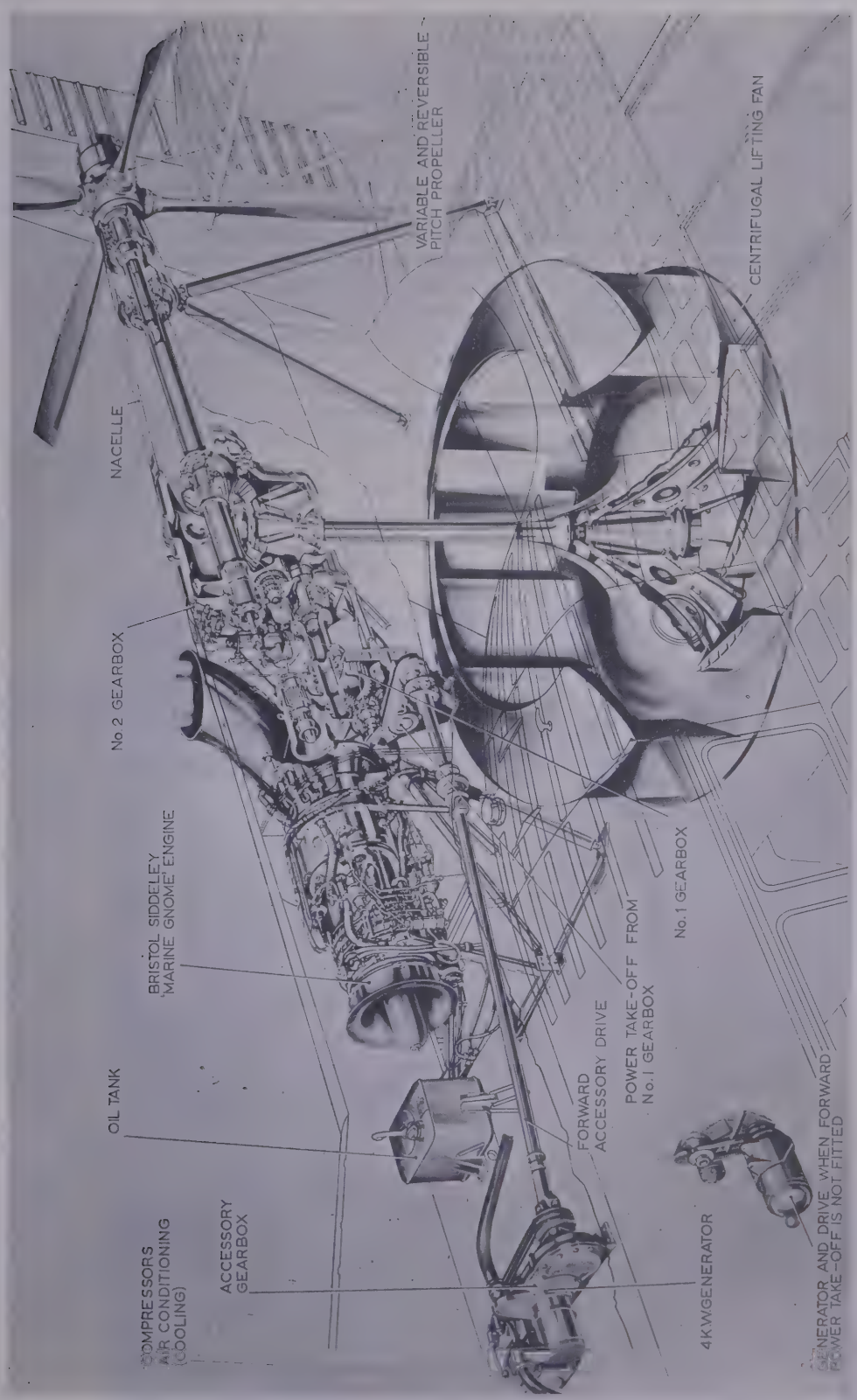

FIG. 4·2 ENGINE INSTALLATION PROPELLER AND FAN DRIVES

CONTROLS

The control system consists of two manually-operated rudders and two all-moving tailplanes, used in conjunction with propeller pitch control, skirt lifting and side control ports. Essentially the rudders are for directional control, while the tail planes are mainly for trimming. The craft can also be trimmed longitudinally by transferring fuel ballast from the aft tanks to the forward tanks and vice versa; the system is controlled by switches on the commander's panel. The engine throttle control is mounted on the propeller pitch control lever, thereby giving the commander single-handed control of height and speed. The rudders and elevators are cable-operated; rudder control is by a standard aircraft-type rudder bar, the elevators being controlled by a lever at the right-hand side of the commander's seat.

Low speed manoeuvring is by raising sections of the peripheral trunk by hydraulic jacks and cables through a joystick type of control. The control operates four selector valves each one operating a jack to raise a section of the trunk. The control can be locked in any desired position and it is arranged so that it acts in the natural sense. By lifting the trunk to spill cushion air the craft is tilted and the resultant thrust component obtained moves the craft in the direction of the lifted trunk.

Four ports, two forward and two aft, direct air bled from the plenum chamber sideways and thus provide yaw control. The ports are interconnected diagonally and controlled by a switch on the commander's panel enabling the air to be directed as desired.

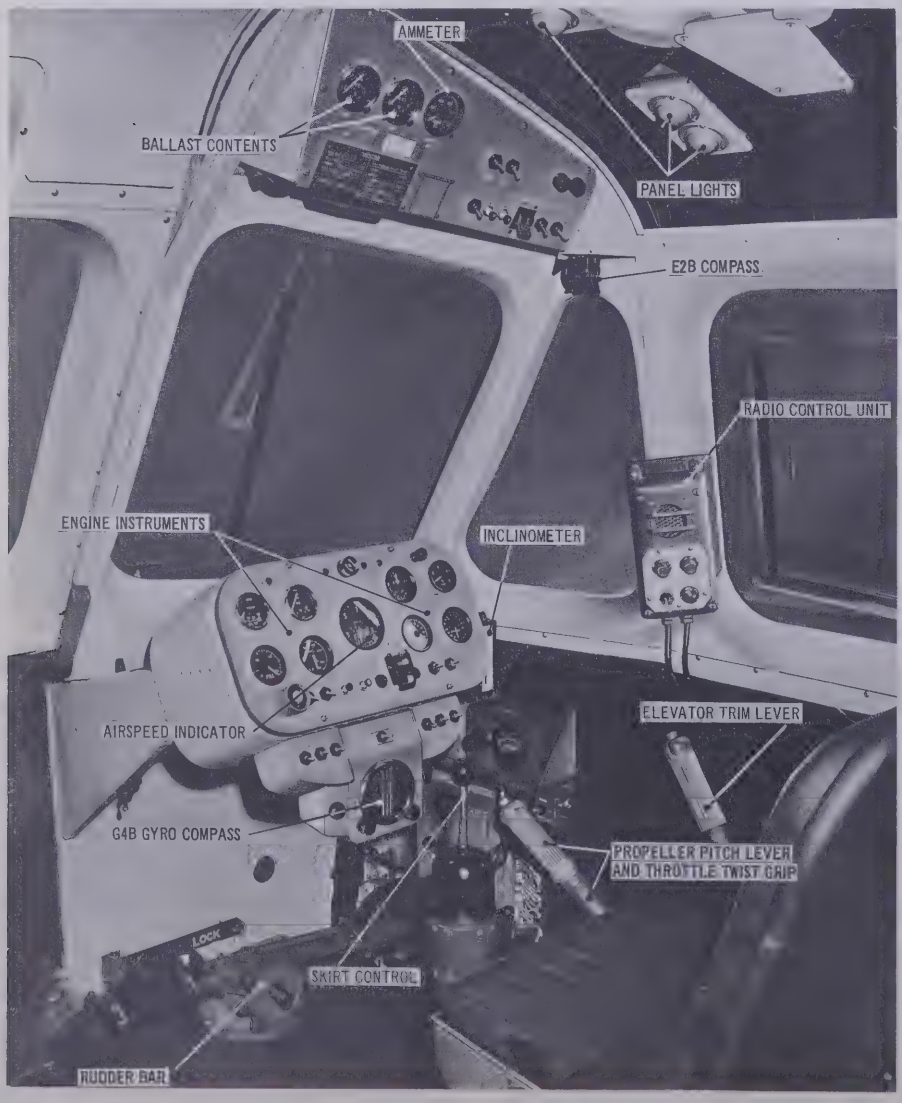

FIG. 4·3 COMMANDER'S CONTROLS AND EQUIPMENT

FUEL SYSTEM

The engine is designed to operate on a wide choice of fuels from 'wide cut' kerosene to light diesel fuel. The complete system is contained in a bay aft of the cabin rear bulkhead and is accessible from deck level through a hinged panel.

The fuel is contained in a 265 Imperial gallon bag tank and is delivered to the engine by an electrically-driven pump mounted on top of the tank, the drive extending through the tank to drive an impeller in the tank sump. The pump can deliver fuel to the engine at a rate of 100 gall. (457 litres) per hour at a pressure of 8 to 10 p.s.i. (0,56 to 0,7 kg./sq.cm.). A conventional float-type contents transmitter is fitted in the tank and is connected to a gauge on the commander's panel. Refuelling is by gravity through a filler neck in the upper decking on the port side of the engine.

In an emergency approximately 45 gallons of fuel can be transferred from the ballast system into the main tank.

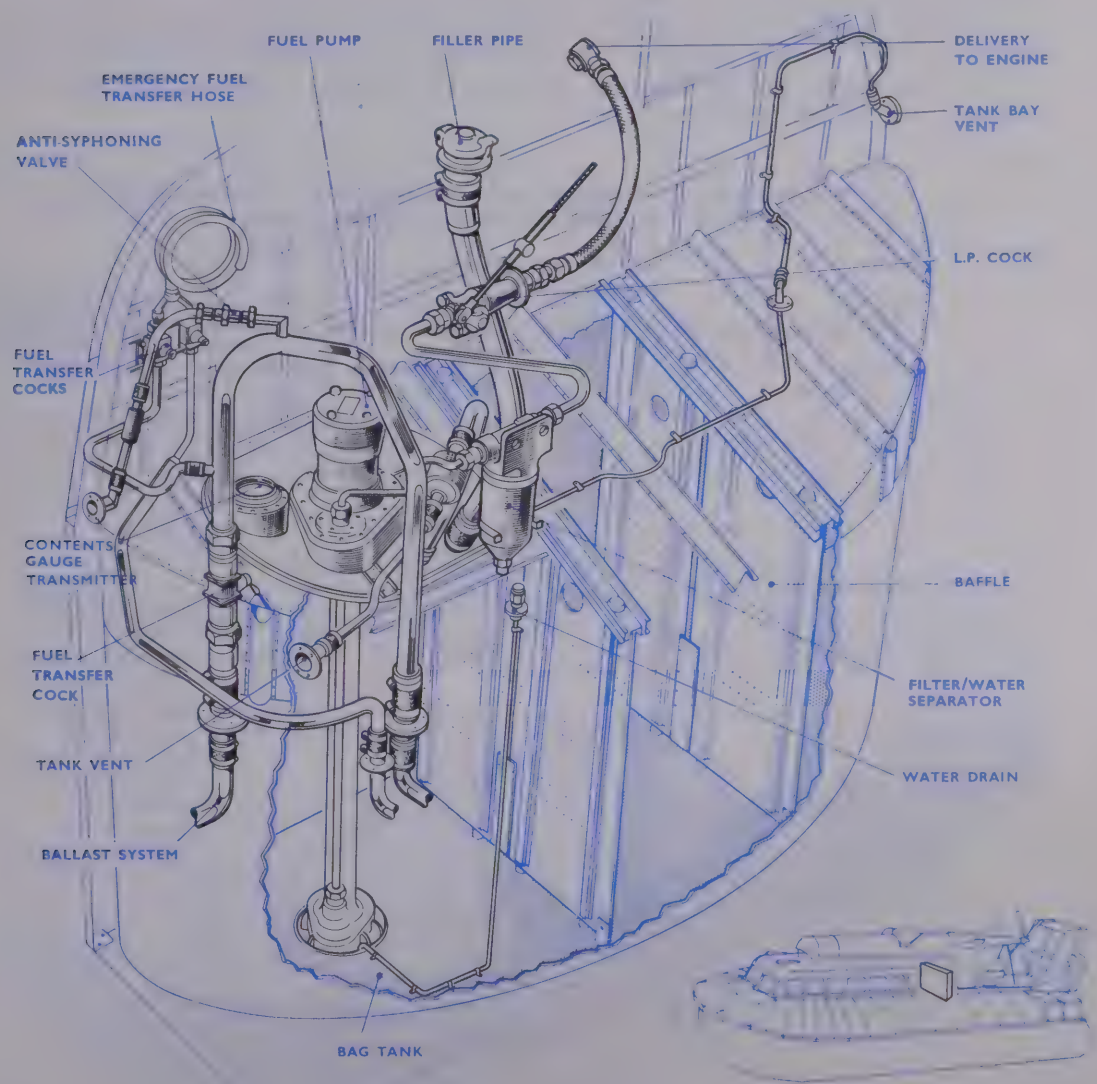

FIG. 4.4 FUEL SYSTEM

OIL SYSTEMS

The system has the dual function of lubricating the engine and gearboxes and of supplying pressure oil to operate the propeller pitch-changing mechanism the skirt lifting jacks and the side control jacks. The common oil supply is contained in a $4\frac{1}{2}$ Imperial gallon tank installed in the engine nacelle. Two oil coolers are provided, one, which is of the fuel-cooled type, for the engine oil, and one for the remaining services; this latter utilises air from the plenum chamber.

Lubricating oil for both gearboxes is circulated by a pump driven by No.1 gearbox and scavenged by a pump also driven by this gearbox; oil from No.2 gearbox drains under gravity into No.1.

The lubricating oil pump also supplies two booster pumps driven by No.2 gearbox, one increases the pressure to 400 p.s.i. for operating the propeller pitch-change mechanism and the other increases the pressure to 2,000 p.s.i. to operate the skirt lifting and side control jacks.

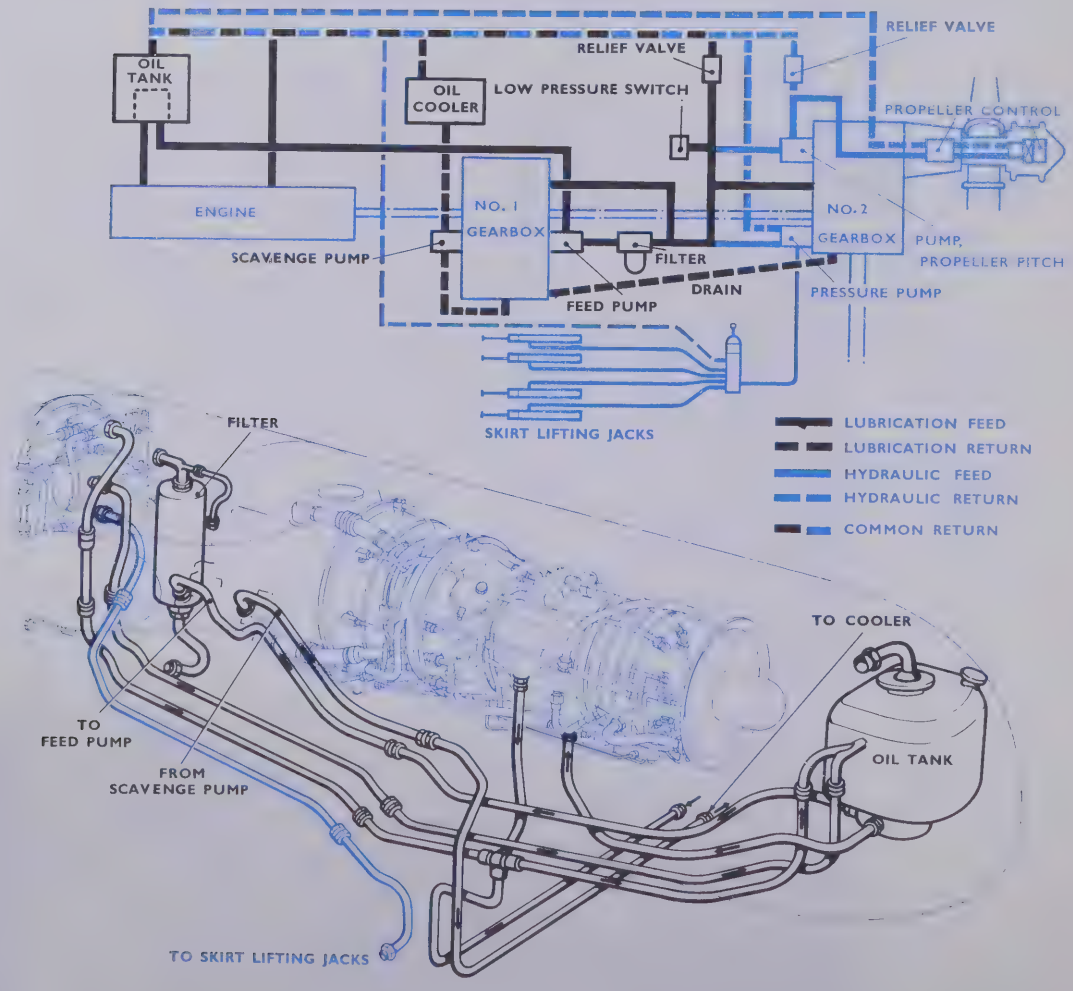

FIG. 4.5 OIL SYSTEMS

BALLAST SYSTEM

The ballast system enables the craft to be trimmed longitudinally under load carrying conditions and to offset changes in trim due to aerodynamic conditions.

The system comprises three tanks, one mounted centrally aft and two forward, one to port and one to starboard, the aft tank is in two portions and these are connected one each to the port and starboard forward tanks by a system of pipes.

Initially the aft tank contains 45 gallons of fuel ballast, $22\frac{1}{2}$ gallons in each side, and this can be apportioned as required between the aft tank and the two forward tanks. An immersed fuel transfer pump in each tank, controlled by switches on the commander's panel, enables the attitude of the craft to be adjusted to suit prevailing conditions, by transferring fuel ballast between the forward and aft tanks. A contents gauge transmitter is provided in each side of the aft ballast tank and is electrically connected to an indicator at the commander's station.

The system is so designed that the fuel ballast will not transfer under gravity due to the attitude of the craft, e.g., when climbing an incline, nor will it syphon after a transfer operation.

In an emergency approximately 40 gallons of the fuel ballast can be transferred to the main fuel system.

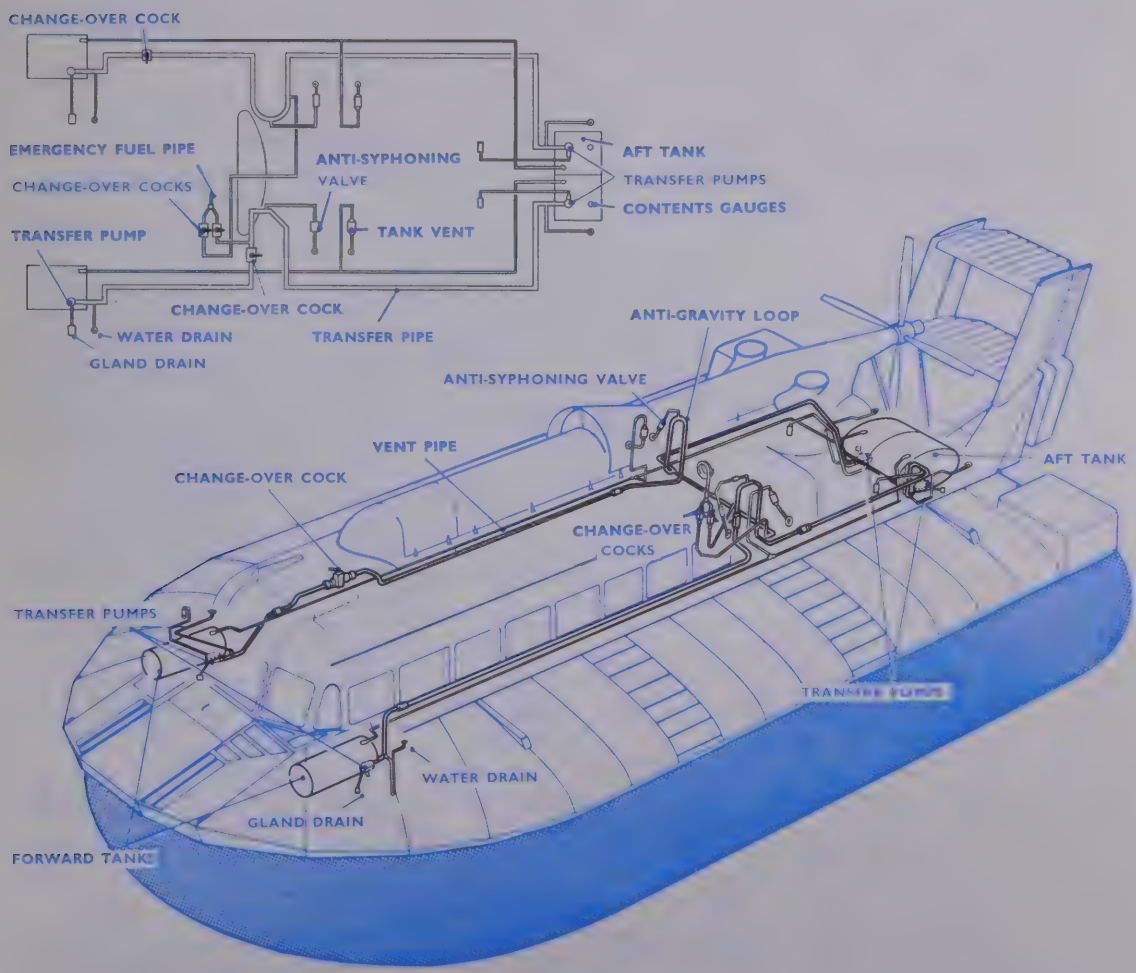

FIG. 4.6 BALLAST SYSTEM

AIR CONDITIONING SYSTEM

Cabin ventilation is provided on the basic machine and is by an extractor louvre in the cabin rear bulkhead through which air is drawn by the main lifting fan, this causes replacement air to flow into the cabin through a ventilator in the roof.

Provision is made in the design for the installation of a full air-conditioning system incorporating heating and refrigeration units; alternatively the heating system alone can be installed.

An intake at the forward end of the dorsal pod provides ram air for the air-conditioning system. This air is either cooled or heated as required and in both cases is mixed with cabin air which is being re-circulated. Two fans are used to boost the air supply to the cabin.

The air cooling system is of Normalair design and consists of a closed refrigerant circuit which utilizes the latent heat of evaporation of a liquid refrigerant to cool the air flowing through the cabin air re-circulation system. Warm air from the cabin passes through an evaporator matrix which extracts heat from the air before it is directed into the cabin. A compressor circulates the refrigerant through the evaporator after which it is passed through condensers in which the gas is converted into a liquid; the refrigerant then flows into a liquid receiver for re-circulation.

Hot air for the cabin heating system is supplied from the engine compressor and is directed into the cabin air re-circulation system through a pipe in which is fitted a control valve.

With the exception of the extractor louvre the air-conditioning system is under the complete control of the driver. A lever for controlling the intake of ram air is in the cabin roof and switches on the roof panel control the booster fans, a magnetic clutch, which operates the cooling system compressor, and an actuator for operating a heater control valve.

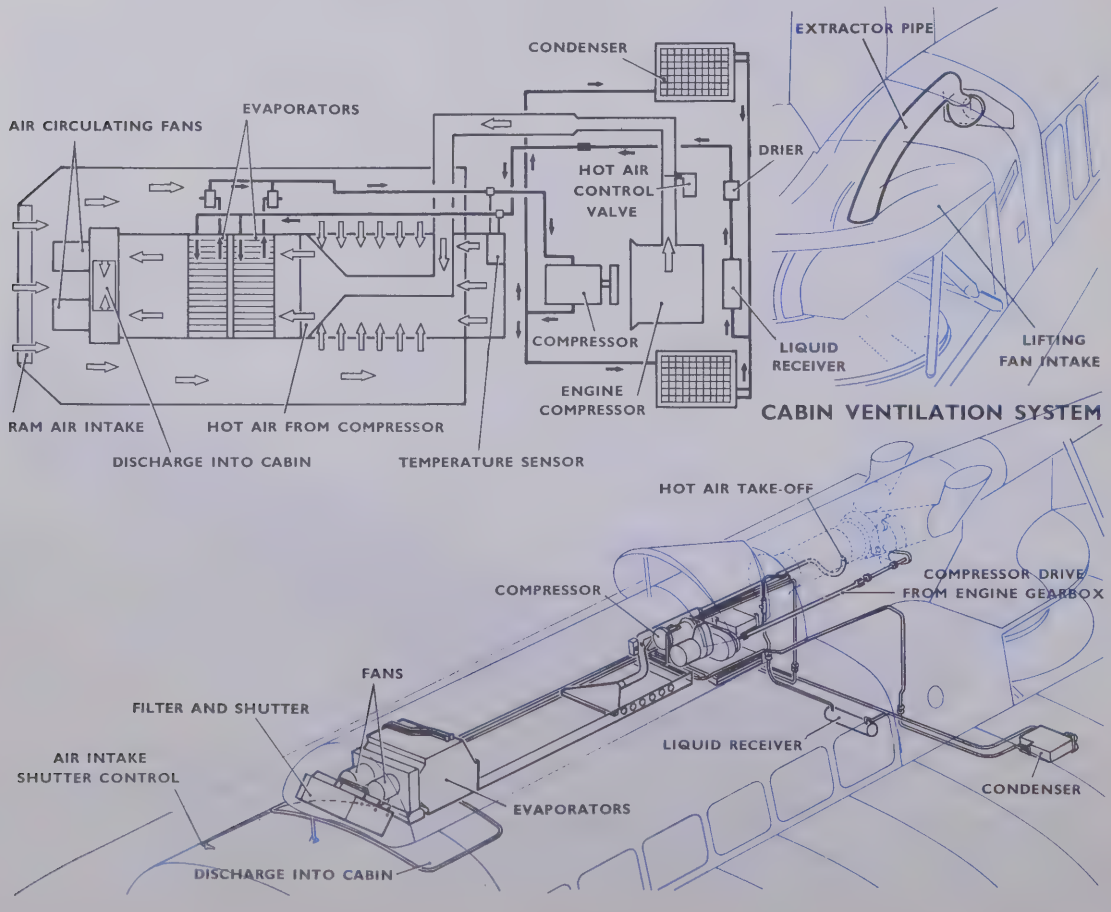

FIG. 4.7 AIR CONDITIONING SYSTEM

ELECTRICAL SYSTEM

Power for the electrical services is provided by a 24-volt negative earth return system and, wherever possible, equipment well-proven in the commercial field has been specified. A Westinghouse engine-driven alternator provides a power output of 140 amps. which is controlled to 28 volts by a voltage regulator. The system is protected by an over-voltage trip unit and operates in conjunction with a 24-volt lead acid battery; a plug for connecting an external power supply is provided. The alternating current required to operate the engine over-speed and over-temperature trip units and the navigation instruments is provided by a rotary inverter that converts the generated d.c. into 115V, 400 c/s, 3-phase a.c.

Electrical services provided include engine starting by electric motor and a high energy ignition unit which can be operated from the battery. Other circuits include internal and external lighting, fuel and ballast pumps, fire detection and radio. 'Therglass' electrically-heated windscreen panels are fitted at the centre and starboard positions; these panels are also provided with windscreen wipers and washers.

The system is designed to withstand the extra loads that could be imposed on it by the fitting of additional equipment such as air conditioning, special radio and night operation equipment.

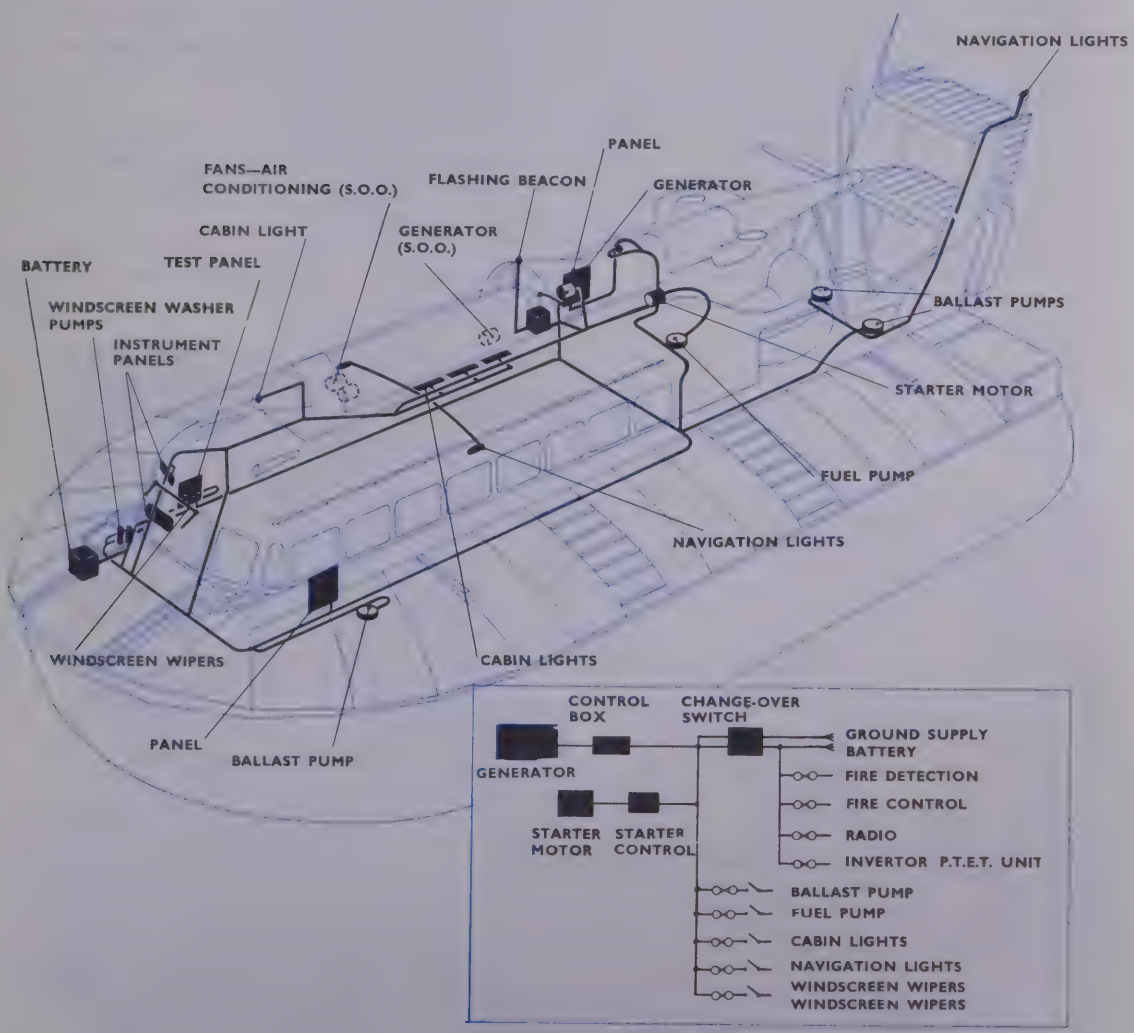

FIG. 4.8 ELECTRICAL SYSTEM

SERVICING

The design of the SR.N6 is such that most of the items requiring maintenance are grouped in easily accessible areas and the need for special equipment, such as servicing platforms, access ladders etc., is quite unnecessary. For example, when the craft is resting on its pads the deck is only 3 ft. 6 in. from the ground and is accessible via the walkways or the loading ramp. All replenishing operations and almost the whole of the daily inspection are carried out from the deck level. For major overhauls the whole of the engine and transmission can be removed and replacements fitted without breaking down the structure in any way.

The fuel system is concentrated in a bay aft of the cabin and is completely accessible through a hatch which also gives access to the engine fire extinguishing system, fuel transfer cocks and oil cooler. All bilging points are in the deck and it is necessary only to attach a simple bilging pump.

For major inspections the craft is easily lifted by a single crane with slings attached to four strong points, two in the forward deck and two in the aft deck and is then supported by stands, one under each landing pad. This enables the skirts to be removed and work on the underside of the craft carried out in comparative comfort.

As a result of experience gained on trials and in service a servicing pattern has been evolved which is a very reliable guide to the degree of servicing that can be expected when operating the craft. A complete servicing schedule is included in the manuals supplied with the craft.

When the craft is delivered a log book is supplied which contains certificates of design, construction and performance, together with a permit to operate. History cards are provided in the log book for all lifed items and include the hours of utilization and overhaul life.

Inspection between sorties is not required unless there is a report of any incident. Daily servicing consists essentially of inspections, replenishments and cleaning and does not require the engine to be run.

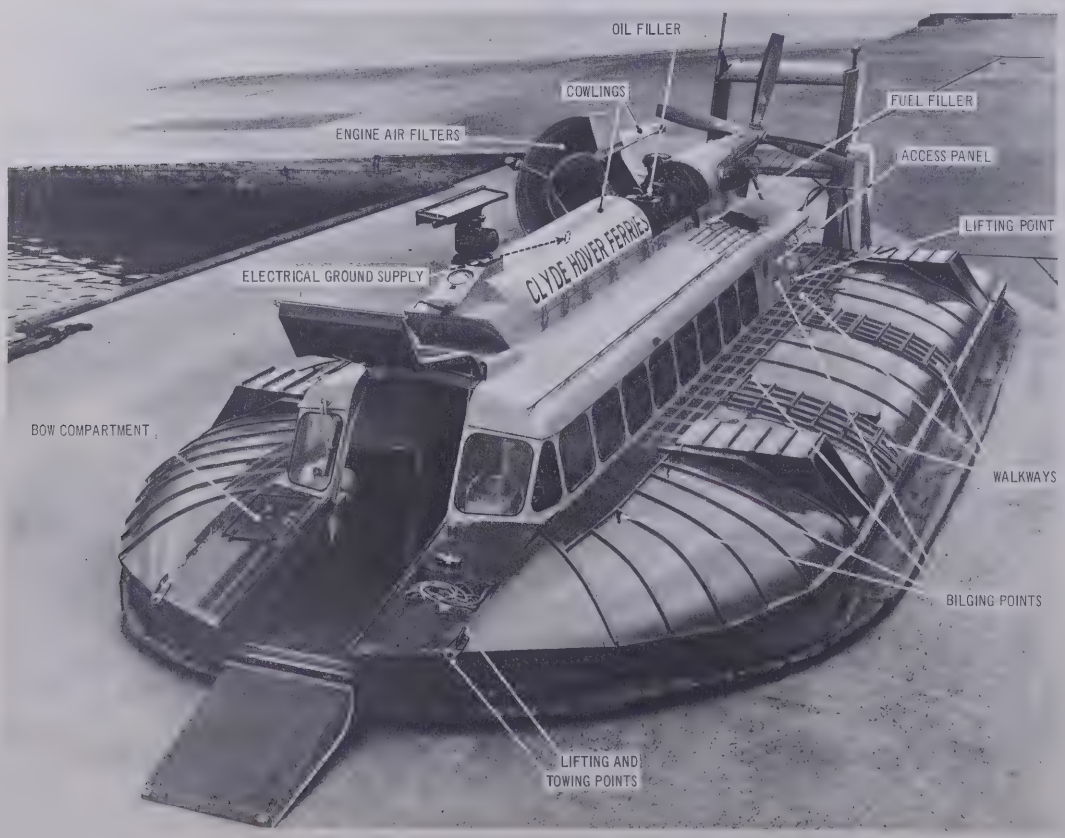

FIG. 4·9 SERVICING FEATURES

In addition to the daily inspection the servicing schedule is divided into 'checks'. The intervals at which these 'checks' are made are initially at recommended periods but these will be extended with experience and can also be adjusted to the requirements of opportunity servicing.

TRANSPORTATION

The craft is designed for ease of transportation and can be conveyed by road on a standard trailer after removal of the skirts and side buoyancy tanks, these are carried on a separate vehicle. In this condition the loaded craft has an overall height of 16 ft. 5 in. and a width of 9 ft. If the craft is transported by sea no dismantling is necessary as it can easily be lifted aboard ship and accommodated as deck cargo.

The only service affected by the preparation for transportation is the hydraulic system to the jacks for skirt lifting and operating the side control ports, and it is only to the extent of disconnecting a single pipe from each of the jacks. The skirts are secured to the structure by 'piano hinge' type fastenings and are easily detached by withdrawing the hinge pins.

FIG. 4·10 TRANSPORTATION BY ROAD AND SEA

operating requirements

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Servicing facilities	5.1
Base equipment	5.1
General servicing stores	5.4
Servicing engineers	5.4

ILLUSTRATIONS	fig.
Typical operating sites	5.1

operating requirements

Sites from which to operate the SR.N6 hovercraft can be classified into three categories - a temporary site such as would be used for trials or route proving - a 'hoverhalt' that would be a permanent installation and would be adequate if the route stages were comparatively short and it was possible for the craft to return each day to a base that possessed servicing facilities. The third type of site has accommodation for several craft, facilities for the complete servicing of craft and accommodation for passengers; radar and night operating equipment would also be included.

To prepare a temporary site it is sufficient to choose a substantially flat hard-standing which has an approach slope from the water of approximately 1 in 10. Loose stones and projections likely to damage the hovercraft skirt obviously should be removed. Boundary fencing is necessary to prevent the public straying onto the operating area; marker buoys to indicate the approach path would also be required.

When choosing a site for a permanent hoverhalt, accessibility from the landward side is a prime factor to be considered and, if the site was required to be in an existing harbour, it may not be practical to construct concrete ramps. In this case a pontoon connected to the quay by walkways and having a hinged ramp, the free end of which is supported in the water, would be the solution; the fore front only of the craft would rest on the ramp.

A terminal is justifiably more sophisticated there being more traffic to handle and it is here that facilities for the servicing of craft would be sited. Two ramps are a distinct advantage and would not only relieve traffic congestion but would enable craft to make a more favourable approach independent of the wind conditions.

The illustration shows typical sites but these would of course vary according to local conditions. Further information on sites is given in B.H.C. publication SP.1164.

SERVICING FACILITIES

Because of the varying nature of hovercraft routes, the number of hovercraft in service, and climatic conditions, it is not practicable to state precise requirements; the information contained in the following paragraphs should therefore be regarded as a guide to the servicing facilities required at terminal bases and adjusted to suit particular operating conditions. At intermediate stops full servicing facilities are not required, and the necessity for refuelling equipment will depend largely on stage lengths. The facilities recommended are based upon the craft servicing requirements which are detailed in the relevant Operator's Handbook. Further information on servicing facilities is given in B.H.C. publication SP.1263.

Essential features of a servicing base are ease of access for heavy vehicles such as cranes or refuellers, and the provision of hard standings, preferably of concrete or transportable interlocking perforated steel plate, to form a firm base for lifting and jacking operations. A small workshop building and clean refuelling arrangements are also required.

BASE EQUIPMENT

Covered accommodation

Covered accommodation is necessary to protect servicing crews and those parts of the craft which are exposed when the cabin door and the various access panels are open or removed. Such accommodation could be in the form of a portable, canvas-covered, light tubular structure, easily positioned and removed, and provided with duckboards to fit over the fan intake. In cold weather, servicing crews should be provided with a means of heating, such as hot-air blowers operated by portable gas cylinders. Warmth is also essential to certain bonding operations, of which replacing the propeller leading edge erosion strips is an example.

operating requirements

BASE EQUIPMENT

Essential Services

The following services are required :-

Electrical power supply for lights, drills and soldering irons, and 28-volt d.c. supply for craft ground supply and battery charging.

Fresh water for engine washing and craft cleaning. Water for engine washing must be very clean, at least to the standard of drinking water. A supply of distilled water should also be made available for electrical batteries.

Telephone communication.

Although not essential, a compressed air supply, provided from storage cylinders or a trolley-mounted compressor, would be useful for cleaning the craft fire extinguisher spray rings and powering riveting tools.

Oil and Fluid Store

Oil and other fluids must be kept scrupulously clean in a weather-proof store capable of holding a small number of 40 gall. (180 litre) drums, together with dispensing equipment. The importance of keeping fluid clean cannot be over-stressed. Recommended lubricants are given in the table and stocks suitable for one or two craft are as follows :-

Fire Fighting Equipment

Subject to compliance with local fire regulations it is recommended that the operator provides :-

(1) A 25 lb. (11,3 kg.) CO_2 or B.C.F. extinguisher fitted with a Pyrene bayonet coupling for attachment to the external socket of the craft engine bay.

(2) From four to six 2 gall. (9 litres) hand-held foam extinguishers.

Lifting Equipment

Lifting equipment is required to raise the craft onto its special stands for inspection of the flexible trunks and the under-side of the craft. This can be in the form of a crane or gantry, or portable jacking equipment designed by B.H.C. When suspending the craft use must be made of the special craft slings, which normally require a hook height of 13 ft. 6 in. (4,1 m.) before lifting. The crane or gantry, which must be capable of smooth, low speed operation, must also satisfy the following minimum requirements :-

Minimum safe working load	6 tons
Lift (from a starting hook height of 13 ft. 6 in.) (4,1 m.)	4 ft. 6 in. (1,4 m.)

If a single-jib crane is used, the starting hook height is increased to 19 ft. (5,8 m.), and a reach of 14 ft. (4,3 m.) is required.

Special slings are available for lifting the engine and propeller.

TEMPORARY SITE

HOVERHALT

FIG. 5·1 TYPICAL OPERATING SITES

operating requirements

GENERAL SERVICING STORES

The range and quantity of general servicing stores required will vary according to the number of craft, their rate of use, type of route etc., and intending operators should consult B.H.C. about their requirements.

SERVICING ENGINEERS

The following personnel are the minimum number required to maintain two craft in continuous service :-

(1) Two approved engineers.

(2) Four other engineers.

(3) One electrical engineer, preferably with radio experience.

Until British, or other government agency approval is required for hovercraft servicing engineers, such personnel will be approved by B.H.C. or its licensees by examination following a course of instruction. It is recommended that the non-approved engineers attend instruction courses on their hovercraft whenever practicable.

Engineers should preferably have had experience of aircraft maintenance, and a knowledge of light-alloy construction, hydraulic systems, gas turbine engines and their associated systems, and aircraft propellers.

customer proposal

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